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THE

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NOTES.

Barnsley.—The Council have considered plans for their central station buildings, which are to cost about £3,000.

Naval Exhibition.—Messrs. Willans and Siemens have the lighting of this exhibition. We gave the number of lamps in our last issue.

Refining Copper.—We learn that at Nijni Novgorod, work on a somewhat extended scale has been carried out in the electric refining of copper.

Aberdeen.—A new telegraph wire has been put up between London and Aberdeen. This makes the third wire available for private and trade messages.

Prof. Tyndall.—We are glad to learn that Prof. Tyndall has enjoyed better health lately, and is recovering from the attack of insomnia from which he has been suffering.

Swansea.—The Corporation, acting on the advice of Mr. W. H. Preece, have accepted the tender of Messrs. R. E. Crompton and Co. to put up 23 arcs at a cost of £25 per lamp per annum.

New Zealand Syndicate.—We notice that this syndicate, which was mentioned at the recent meeting of the Gulcher (New) Company, has been registered with a capital of £30,000 in £10 shares.

Society of Arts.—Among the papers down for reading in the new year, but for which no date has yet been fixed, is one by Messrs. H. Newman Lawrence and Arthur Harries, M.D., on "Electricity in Relation to the Human Body."

Exeter.—The Town Council have decided to insert the sum of £30,000 in their order as the amount to be spent on electric lighting works. The town clerk has estimated that the cost of obtaining this order will amount to £300.

The Telephone in Sheffield.—During Christmas week 56,188 messages passed through the Sheffield Telephone Exchange. The total for the 31 consecutive days ending on Christmas Eve was a little over a quarter of a million.

St. Helens (Lancs.).—The Corporation Gas Committee has appointed a sub-committee to consider and report upon the question of the supply of electricity within the borough with a view to its being provided at an early date.

The Telephone in Germany.—It is proposed to run a telephone line between Stuttgart and Frankfort-on-Main. Another scheme on hand is a line running from Cassel through Eschwege, Mulhausen, Sondershausen, and Nordhausen to Berlin.

Edinburgh.—The directors of the Edinburgh Philosophical Institution gave a children's evening on Tuesday night, which was a great success. The proceedings were opened by Lord Kinsburgh, who interested the youngsters in that very interesting subject, "Electricity."

Acme Works.—A West-end showroom has been opened by the Acme Electric Works, in Princes-street, Hanover-square. A complete installation is being fitted up, and a large stock of their fittings, pendants, and the latest and best types of switches are there to be seen.

Telegraph Line Interrupted.—Owing to a fire breaking out in a rag warehouse at Woodbridge, Suffolk, on Monday morning, telegraphic communication between England and India and the Continent was interrupted for about six hours. The wires were repaired in the course of the day.

The (New York) "Electrical Review."—We are informed that the London offices of this journal have been removed from 181, Queen Victoria-street, E.C., to the Hotel Victoria, Northumberland-avenue, W.C., where Mr. Charles F. Ffrench will continue to act as London editor and manager.

Cardiff.—At the meeting of the Cardiff County Council on Tuesday, the town clerk reported that the usual parliamentary notices had been deposited on behalf of the Corporation for an Electric Lighting Bill, the amount of capital to be expended being named at £24,000. This applied simply to the compulsory area.

Brighton.—The Town Council have decided to substitute telephonic for telegraphic communication between the Town Hall and the fire and police stations. Besides effecting a saving of much valuable time, this will also be economical from a monetary point of view to the tune of £55 per annum. At least, so it is stated.

Maidstone.—As the Local Board recently passed a resolution that they would oppose the application of the Electric Installation and Maintenance Company for an order, the company has written saying that in the event of the Board deciding to carrying out the lighting themselves they will be happy to negotiate with them.

Penzance.—At the last meeting of the Town Council a draft provisional order was received from the Board of Trade. This, taken in connection with the Lighting Committee's report, which called attention to the bad quality of the gas and its poor illuminating power, looks hopeful for electric lighting in this pleasant little Cornish town.

Motors at Kensington.—Electric motors are being put in at Barker's Universal Stores, High-street, Kensington. They are driven off the Crompton circuits, and are to be used for chaffcutting, coffee grinding, and other similar purposes. The public use of these electric motors will be likely to lead to their employment in many other places on the circuit.

Gas and Electric Lighting.—Now that the use of the electric light is really spreading, why does not our great gas company push the use of gas for heating? asks Mr.

G. J. Symons, almost plaintively. It's what we want to know, too, for when all is said and done it's about the only thing, besides driving gas engines, for which gas is fit.

Paris.—The Continental Edison Company are building an important electric station in Paris at the Avenue Trudaine. The works are well advanced, and it is hoped to begin supply this winter. Great efforts are being made to obtain the concession for the Boulevard St. Germain for the Ferranti system, as embodied in the Compagnie Nationale de l'Electricité.

Barnet.—Considerable discussion has been going on here as to the cost of the electric lights for the past year. The contractors (Messrs. Joel) make out a balance in their favour as against gas; on the other hand, of course, there are those who turn the figures round and bring out a balance against the electric lights. We are afraid that the net result of all this warfare in print will not be of much use to anybody.

Cleckheaton (Yorks.).—A committee of the Local Board has been appointed to confer with the Town Hall Committee as to lighting that building electrically. A member of the Local Board has estimated that the lighting will cost £1,700 or £1,800, but others think this far too high. The Board and the gas company are at loggerheads, the former wanting a reduction and the latter declining to give it.

Bournemouth.—At the last meeting of the Town Council, the Lighting Committee reported having had before them a letter from the Board of Trade, forwarding the report and balance-sheet of the Brush Electrical Engineering Company. The clerk was directed to reply that the accounts furnished seemed to show that the company were in a position to discharge the duties imposed upon them by their order.

Edinburgh Exhibition.—The liquidator, Mr. J. A. Robertson, C.A., has received a fairly prompt response to his request for payment of the sums for which the guarantors are liable. The guarantee fund amounted to about £26,000, and of that upwards of £23,500 has been received and lodged in the bank. The balance unpaid includes the amounts guaranteed by several corporations, who will no doubt authorise payment at their next meetings.

Foreign Telegrams.—The council of the Leeds Chamber of Commerce have decided to call the attention of the Postmaster-General to the omission made, during the last two or three months, to state upon foreign telegrams the hour and the date upon which they were sent. The omission was regarded as of importance, since the time at which a message was despatched had not unfrequently a bearing upon the price at which goods were to be supplied.

Personal.—We hear that Mr. W. J. Hammer has recently opened an office in New York as consulting electrical engineer. Mr. Hammer came over to England in the old Edison Company's service, and made many friends. He subsequently did a lot of work in Europe. We wish him all success in his new venture. The last time we had the pleasure of seeing him was when he represented Mr. Edison at the 1889 Paris Exhibition, and paid a short visit to London *en route.*

"The Deep C."—The following story may be new to some of our readers. We do not vouch for its accuracy: "The late Dr. Joule, of Manchester, was a welcome, if occasional, visitor to Sir William Thomson, they being old friends, and the story is told that at the period when Sir William was bringing out his sounding machine, in which steel wire takes the place of the ordinary lead line, he showed Dr. Joule a bundle of pianoforte wire, telling him at the same time that it was for 'sounding.' 'What note?' inquired Dr. Joule, not quite understanding. 'The deep C,' promptly replied Sir William."

Vaison (France).—The town of Vaison (Vaucluse) is lighted electrically. The generator is a Zipernowski alternator, with an output of 23 kilowatts, placed some 2·5 kilometres from the town. The pressure in the distributing mains is 1,800 volts. Another small town in Vaucluse is also to be lighted shortly, a 20-kilowatt alternator being used. Vaison has but 3,000 inhabitants. Both these installations have been carried out by Messrs. Lombard, Gerin, and Co., of Lyons.

South African Lighthouses.—The report of the Cape Lighthouses Commission considers that single lights on the coast are dangerous, and that coloured lights should be avoided as leading lights, which should be the most powerful procurable, and should be visible at a distance of not less than 17 miles, and that all the principal lights should be flashing. The Commission also recommends the erection of a lighthouse on Dassen Island, which would give an altitude to the focal plane of light of about 150ft. above the sea level. Electric lights should be wanted for the most powerful lights procurable.

The London and Paris Telephone.—At the end of last week the wires for this line has been advanced as far as Ashford, there being about 25 miles to complete the English land wires. This work is being performed by a corps of the telegraph department men of the Royal Engineers, who number altogether about 60 and work in gangs at different points on the route. There are four wires, constituting two metallic circuits. The Post Office telegraph steamer "Monarch" has been engaged during the week in laying the telephone cable across the Channel, between St. Margaret's Bay, Sandgate, and West Calais.

Abercanaid (Wales).—This little mining village, which is near Merthyr, has been lighted electrically. The initiative was taken by Mr. T. H. Baily, general manager of the Plymouth Collieries, who arranged for the lighting in connection with the Local Board. The necessary apparatus was supplied by Mr. J. C. Howell, of Llanelly. The dynamo is by Crompton, and there are 25 incandescents of 32 c.p. These replace 14 oil lamps, which have hitherto lighted the village, and cost £4. 10s. each per annum, or £63, against £80 per year for the incandescents, of which, however, there are nearly double the number, giving considerably more light.

Photography by Electromagnetic Waves.—From Vienna it is reported that Herr Dombrzynski, of the Lemburg Polytechnic Academy, has succeeded in photographing by electromagnetism. It is also said that he has explained the means by which he succeeded in so doing, in a paper addressed to the Vienna Academy of Sciences. Whilst this success, if true, will be of the greatest interest to scientific men, as throwing further light on the relation between electromagnetic and light waves, we can hardly believe that the present very effective method of utilising actinic rays of light will be superseded in photographic matters by the new method.

Logarithms.—Messrs. Poole and White send us a very handy sheet of four figure logarithms. Anyone who has to calculate out many formulæ knows the value of logarithmic methods, so that into that we need not enter. Not only, however, does the sheet contain a table of logarithms, but a table of the values and logarithms of a number of constants and coefficients that come into electrical calculations, also a calendar for 1891, and a celluloid tablet on which the calculations can be made. The whole is folded into a small morocco case, and can be carried easily in the pocket or pocket-book. Altogether this is an extremely neat and useful sheet.

Newcastle-on-Tyne.—At a meeting of the Town Improvement Committee last week, a deputation from the Newcastle Electric Lighting Company attended with reference to the recent decision of the Council not to sanction an order for a longer period than seven years. Mr. Milburn, the chairman of the company, pointed out that the demand for electric light was so great that their present works would have to be extended, and this, and other matters pertaining to the subject, led the company to express the hope that the matter would be reconsidered, and the time asked for (42 years) allowed. The committee intimated that the application made by the deputation would be considered.

Wood Casings and Rats.—We are informed by one of the best possible authorities on the subject that no rat or mouse has been yet known to have eaten through wood casings in order to get at the conductors therein, although they have gnawed through metal tubes, and injured the insulation of the leads contained in them. Considering that very few buildings are without these mischievous rodents, and in view of the immense amount of damage that may result from their attacking the insulation of leads, we think the above fact is worth knowing. If any of our readers has any evidence to adduce either one way or the other, we shall be very glad to make it known through our columns.

Temporary Lighting.—On Saturday evening last, at the Westminster Town Hall, Messrs. John Broadwood and Sons gave a party to the children of their large staff of employés. The guests numbered about 800, and a feature of the entertainment much appreciated by the youngsters was the illumination of the gigantic Christmas tree with about 90 incandescent lamps, and the hall itself with about 100 more, hung in festoons under the balcony, the wires being covered with holly and other suitable decorations. The current was supplied by the Westminster Supply Company (gratuitously), the temporary lighting being carried out by Messrs. Girdlestone, Tatham, and Co., of Davies-street, Berkeley-square.

St. Louis, U.S.A.—The alternating current electric lighting plant of the Missouri Electric Light and Power Company, in St. Louis, Mo., has grown so rapidly that it has now become one of the largest central station plants of alternating-current electric lighting in the United States. The company was organised in the early part of 1887, with apparatus of a generating capacity of 12,000 lights. This, says an American paper, was the first contract for Westinghouse alternating-current apparatus which had come from St. Louis. Now the company have alternating-current apparatus with a generating capacity of 24,000 incandescent lamps, which makes theirs the largest alternating-current central station plant in America, west of the Allegheny mountains.

Plymouth.—It appears that the work of establishing a telephonic signal station on Rame Head, off Plymouth, is being delayed by the Admiralty, who apparently require a great deal of time to answer the apparently simple question "What accommodation must be provided for the men working the station?" This fearfully difficult task has been almost too great for the good people at Whitehall, and so, although the land wires are up and the cable is ready to be laid, the Western Counties Telephone Company cannot complete the job, because there are no men at the station to work the line. If the Admiralty had had nothing to do with the matter, and everything had been left to Mr. Lewis, the energetic manager of the company, we can confidently say that the line and station would have been working long ago.

Burlington Arcade.—After great discussions, *pros* and *cons.*, wonderings and heartburnings, the Burlington Arcade has at last been lighted by the electric light. The arcade itself is lighted by a row of pendants with white opal shades and 50-c.p. lamps, supplied by current from the St. James's circuit. The light is a great improvement on the few glimmering gas lights hitherto employed. Several of the shops have already adopted the light inside, and all may be expected eventually so to do. The work of fitting up the arcade has been carried out by Messrs. Freeman and Co., of Swallow-street, Piccadilly. It has been long a wonder why such a place should not be lighted by electricity, but the difficulty of getting the numerous tenants to agree on the extra expense involved has, no doubt, prevented it being done sooner.

Glass Insulators.—A significant fact in illustration of the way work goes abroad may be mentioned in connection with the special glass insulators used in Crompton's system of underground mains described elsewhere. When the system was first drawn out on paper, and the design of insulator decided upon, a quotation was asked for from several English firms with a request for specimens to be submitted. Without exception those asked refused to do this unless a definite order for so many thousands was given. At this juncture a German representative called, saw the design, at once offered to submit samples, quickly did so, with the result that orders for tens of thousands of these glass insulators have gone to Germany. Thus does want of enterprise on the part of English manufacturers bring about its own punishment.

The Gas Journals.—The *Journal of Gas Lighting* in its annual review is good enough to say that "the electric lighting industry has, in a sense, prospered during the year." We quite agree with our contemporary, though, perhaps, our sense of the way in which the industry has gone ahead is not its sense. We, however, demur entirely to its statement that "of accidents and fatalities in connection with the coal-gas industry, the year was happily barren." So far as our recollection goes, hardly a week has passed without its record of gas explosions, little and big. The *Gas World*, in speaking of its friendly rival in London, says: "It is not our intention to deny that the electric light has made progress: it has made progress, and that it will make more cannot be doubted; but we think we have had sufficient evidence to enable us to assert that any progress it may make in the future will not adversely affect the gas industry."

Splicing Carbons.—The electric lighting company of Concord, N.H., is using a device by means of which, it is stated, a saving of 30 per cent. is effected in the cost of arc lamp carbons. The trimmers bring to the station all the short pieces of carbon collected on their daily rounds. These are sorted and matched together, to form a carbon about 8in. in length. These pieces are placed in a machine which forms a dowel on one piece and a socket in the other, and they are cemented at the joints. The cement with which they are joined is heat-proof and is a good conductor, so that there is no change in light indicated when the joint is reached. The spliced carbons are used only in the lower holder. Carbons thus joined have, says the *Western Electrician*, been used by the company over a year, and the process is considered entirely successful. A patent for the process has been taken out by Messrs. N. P. Stevens, machinist, and W. A. Richmond.

New Cruisers.—H.M.S. "Sybille," a new cruiser, which has been built by Messrs. Robert Stephenson and

Co., of Hepburn-on-Tyne, was launched last Saturday. She is 300ft. long, 43ft. wide, with a displacement of 3,400 tons on a draught of water of 16½ft. Her engines, which are being supplied by Messrs. R. and W. Hawthorn, Leslie, and Co., St. Peter's, Newcastle, are capable of developing 9,000 i.h.p. with forced draught, and the vessel is expected to be driven by her twin screws at a speed of 20 knots. She is armed with two 6in. guns, six 4·7 guns, nine smaller quick-firing guns, four Nordenfelt guns, and one boat's gun, and there are four torpedo tubes. Incandescents are fitted throughout, and there are powerful search-lights. The Admiralty have given instructions for a new second-class cruiser, to be called the "Charybdis," to be laid down at Sheerness Dockyard during the ensuing financial year. She will be fitted throughout with electric lights.

Telephone Posts.—The county councils and other local authorities seem bent on crusading against posts along the highways within their jurisdiction. Certainly, these posts should be placed where they will inconvenience the public as little as possible; but it should not be forgotten that they support that which is of the greatest possible public utility. A more absurdly selfish reason for not allowing telephone poles to be erected cannot, we think, be found to beat that enunciated the other day at the meeting of the Westmoreland County Council by a member. The Lancashire and Cheshire Company are running a line between Lancaster and Ulverston, and this gentleman did not see why permission should be granted to the company to erect poles because this particular line would not benefit Westmoreland. If reasons like these are to be acted on, good-bye to all the telephonic extensions in country districts which most of us are anticipating in the near future.

Hexham.—At the meeting of the Local Board on Monday a letter was read from the Northern Counties Electric Light Company, asking if the Board would allow them to submit a scheme for the provision of a generating station and plant, distributing mains, etc. They would be willing to provide the Board with all the necessary apparatus, and to go through the necessary forms for obtaining a provisional order for them, and guarantee the Board by undertaking the whole working of the station for a period of years, or until such time as the Board decided to work the plant themselves, the company receiving a portion of the rentals for doing so. In the event of the Board not wishing to undertake the responsibility themselves, they would be willing to rent from them the water power of the old reservoir to be used as an auxiliary power, and to erect on their own behalf a generating station to supply the public and private lights of the district, and, subject to the Board's consent, to apply for a provisional order next session. The matter was referred to the Gas Committee.

St. Pancras Central Station.—The Electricity Committee have issued the following report: "Your committee have inspected the works at the Stanhope-street station, and find the progress in every way satisfactory. With reference to the other works, all of which are being carried out, the engineer has reported that he has tested the boilers of the Babcock and Wilcox Company at Glasgow, and that everything is satisfactory and the work in a forward state. It is also reported that the engines and dynamos are also well advanced. The Electric Construction Corporation raised some question as to the limit of time for their works, and this has been arranged by the engineer, and it is now understood that the station will be ready for them to proceed with their work on April 15 next, and their work is to be completed within two months from that date. In accordance with the terms of the St. Pancras order, plans of the mains have been deposited with the London County Council and the General Post Office, and one month's notice has been given as required to the gas, water, and tramways companies. Your committee have, therefore, every confidence in informing the Vestry that the whole of the works are progressing satisfactorily."

Another Underground Electric Railway.—The promoters of the South Kensington and Paddington Subway Railway Bill, which was withdrawn in the early part of last session, have re-deposited their measure, with important amendments, in the Private Bill Office of the House of Commons, "for the purpose of affording by the construction of subways north and south communication within the metropolis." Power is sought to construct a subway about 1¾ miles long, commencing at a point near the Exhibition-road, Kensington, and terminating in Paddington at the western end of the Bishop's-road bridge over the Great Western Railway. The first directors of the company proposed to be incorporated for carrying out this scheme are the Earl of Kilmorey, Baron Sudeley, the Hon. E. S. Churchill, Sir J. H. Puleston, Mr. J. Irving Courtenay, Mr. Samson Fox, Mr. G. Newman, Mr. E. Power, and General C. E. Webber. For the construction of this subway, in which the motive power to be employed is "electricity or cable power," a capital of £276,000 is sought to be raised, in respect of which the company will be empowered to borrow an additional sum of £92,000. The professors at the Central Institution and the Science and Art Department, South Kensington, do not look with much favour on this scheme, fearing the effect of passing trains on their instruments.

Town Councillors as Gas Shareholders.—This question cropped up at a recent meeting of the Dover Council, and the remarks made by various councillors are instructive. First of all the town clerk read the subsection of the Municipal Corporation's Act referring to the matter. This states explicitly that a member shall not vote upon or discuss any matter in which he has directly or indirectly any pecuniary interest. Plainly, therefore, a councillor who is also a gas shareholder in the town, could not vote or speak on the question of the introduction of the electric light into Dover. Councillor No. 1 said he should get rid of his gas shares in order to qualify as an opponent of electric lighting. Councillor No. 2 thought that this was only an attempt to stop the mouths of the two or three gas shareholders on the Council. He thought it better to take part in the discussion and voting, and chance another member turning common informer. Councillor No. 3 opined electric lighting was too far off for them to trouble about it. The town clerk having stated that breach of the Act he had read was a misdemeanour, and the Mayor having told the meeting that it would be for him to see the law carried out, the subject dropped. Unless we are very much mistaken, breaches of section 22, sub section 3, of the Municipal Corporation's Act are committed by worthy councillors fairly frequently, and with a light heart.

Prof. Ewing.—A few days ago Prof. Ewing, F.R.S., who has filled the chair of engineering in University College, Dundee, since its opening seven years ago, was entertained to dinner in the Queen's Hotel prior to his departure to Cambridge University. After dinner, Mr. G. W. Baxter proposed the toast of the evening, and in doing so gave a brief sketch of the life of Prof. Ewing, stating that he had a most distinguished career as a student at the University of Edinburgh, and that the Japanese Government unsolicited extended the term of his tenure of office of the Chair of Mechanical Engineering in the University of Tokio from three to five years. During the seven years that Prof. Ewing had been in University

College he had done much excellent work both in civil and mechanical engineering, and as an electrical engineer he had made himself a name which would not easily be forgotten. Prof. Ewing, in reply, said he ventured to claim on behalf of his colleagues, as well as of himself, that they had endeavoured to aim high in University College, and if they had not succeeded in getting crowded benches they had at least succeeded in this: that the work which had proceeded from many of the laboratories had received the warmest possible welcome in the highest places, and that their little college, after only six years of existence, had had the official stamp placed upon it, which admitted it to the membership of the family of the universities of this country.

Telegraphic Communication on Our Coasts.—The action of the Plymouth Chamber of Commerce in advocating a more perfect system of telegraphic and telephonic communication between the chain of coast-guard stations around our islands has been endorsed by the Cardiff Chamber. That body has adopted a resolution, which is to be sent to the next meeting of the Associated Chambers in London, affirming that it is most important that, in addition to the coast guard stations, the lighthouses both on the mainland and also on adjacent islands, as well as the lightships, should be placed in communication with the general telegraphic system of the country. The mover of the resolution passed by the Cardiff Chamber (Captain Pomeroy) mentioned that a cable had been laid to connect Lundy Island with the main land, but no provision had been made for its maintenance (? working). The result was that Lundy might be in the Red Sea as far as communication with Cardiff was concerned, as was shown by the fact that during the last gale there were no less than 40 steamers anchored under the shelter of Lundy, and their owners knew nothing of their whereabouts or what had become of them. In one case the underwriters ran up the insurance 60 per cent., and the steamer was perfectly safe under Lundy the whole time. He added that the "Uppingham," which went ashore on Hartland Point a few weeks ago, might have been saved if there had been telegraphic communication between Lundy and Cardiff.

New Insulating Mixture.—A new insulating compound called "voltite" is thus described. It is composed of a mixture of gelatine (specially made), resin oil, oxydised linseed oil, resin, and paraffin. It is cheap, and contains no sulphur. The proportions of the mixture are: Glove glue (*colle de gant*), 1,000 parts; resin oil, 100 parts; oxydised linseed oil, 500 parts; colophane, 150 parts; paraffin, 250 parts. The glue is prepared by taking the refuse clippings of gloves, and soaking them in cold water for one night. The next day they are strained, and washed in several waters until the water is clear. In an iron boiler there are then placed 1,000 parts of water, five parts of carbonate of soda, and dry glove skin 250 parts. This is boiled for six consecutive hours, the water being renewed as it evaporates. The whole boiling mass is next run over a sieve, across which steam is passed to prevent the gelatine coagulating. The boiling solution is received by a wooden tub, through which a current of warm air is passed for one hour. The residue left in the sieve is boiled up with water for three hours, and when filtered can be used again for dissolving the glue, but this time with only 200 parts of glove skin. The gelatinous solution is put into a boiler with the olein or oleic acid used in candle manufacture in the proportion of—gelatinous solution, 1,000 parts; olein, 80 parts. This is boiled for half an hour, after which 10 parts of caustic potash solution (50 parts water) is added. The boiling is maintained for an hour, so as to saponify the olein and form a soapy pulp. The glove glue prepared, resin oil, linseed oil, colophane, and paraffin are added in the proportions above stated; the whole is boiled until homogeneous. This boiling generally lasts about four or five hours.—*Révue Industrielle.*

"The Scot."—This, one of the largest and most powerful steamers yet constructed for the South African mail service, was launched on Tuesday from Messrs. Denny Bros. yard on the Clyde. She has been built for the Union Steam Ship Company, Limited. Her principal dimensions are—length over all, 500ft.; breadth, 54ft. 6in.; depth, moulded, 37ft. 6in. Her estimated tonnage is 7,000 tons. She will be fitted with two sets of triple expansion engines, which, together, are estimated to develop 12,000 h.p. The engines and boilers have been constructed by Messrs. Denny and Co., of Dumbarton, and the dimensions of the cylinders are—two high-press. cylinders 34½in. diameter, two intermediate cylinders 57½in. diameter, two low-press. cylinders 92in. diameter, each engine having a stroke of 60in. There will be six boilers working at a pressure of 170lb. per square inch, and having 36 of Fox's corrugated patent furnaces. The guaranteed speed of the vessel on measured mile, at an exceptionally deep draught, is 18½ knots, or about 21½ statute miles per hour. The "Scot" is built with a cellular double bottom, constructed to contain 1,000 tons of water ballast, and with 14 bulkheads, 10 of which are carried to the upper deck. The first and second-class saloons will be very spacious, and magnificently fitted and furnished, and the numerous cabins of the first and second class will also be unusually commodious and luxuriously fitted. The ship will be provided with about 710 incandescents. The entire ship and machinery have been constructed under special survey by Lloyd's, the Board of Trade, and Admiralty, the latter with a view to her being placed on the list of armed and subsidised cruisers. The "Scot" was named by Miss Giles, daughter of Mr. Alfred Giles, M.P., chairman of the Union Steam Ship Company.

The Big Fire.—In the course of the disastrous fire in Queen Victoria-street on Tuesday, when several lofty buildings were burnt out, a large iron standard carrying 20 or 30 telephone wires crashed through the roof of one of the houses, the wires being of course broken. It seems to us that, sooner or later, we shall have a really bad accident, after the style of America. Luckily none of the wires belonged to light circuits, but there are places in London where such an incident as that of Tuesday might prove a very serious matter. Underground these wires must go some day, let's hope it won't be necessary to sacrifice a life or two before they are made safe in this way. The conduct of the fire brigade deserves a word of notice, though ordinary language will hardly describe the splendid way in which Captain Shaw and his men worked under exceptionally difficult circumstances. The ladders, hose pipes, nozzles, and men were soon encased in ice, and this rendered the work far more difficult and dangerous than usual. The telephone proved, as usual, of the greatest service in bringing up extra help from outlying fire stations. Perhaps nothing could better have illustrated the value of even a minute or two in the case of conflagrations of this kind than the rapidity with which the flames spread from house to house and floor to floor. Without doubt the introduction of electric fire alarms in combination with the telephone has been the means of saving valuable minutes at the very period when they are most precious—viz., the beginning of a fire. We were sorry to see that Messrs. Davey, Paxman, and Co.'s London office did not escape the flames, but this, of course, will not in any way affect the conduct of their business. Another sufferer was the Gulcher (New) Electric Light Company, whose new showroom in Queen Victoria-street was attacked.

ELECTROLYSIS OF SILVER SALTS.

BY ALEXANDER WATT.

In the early days of electroplating many persons engaged in that industry, and a still greater number who were desirous of following the art as a business, made many experiments with solutions of various salts, with a view to obtain practical silver baths which could be used without infringing patent rights then in force. Amongst those experimenters were several licensees under the patents referred to who were desirous, if possible, of freeing themselves from the heavy royalties which their licenses involved. On the other hand, the patentees of certain silver solutions, which they had obtained the exclusive right to use, being desirous of enjoying a complete monopoly of the whole electroplating trade, endeavoured to secure by further patents every available silver solution from which the metal could be deposited by electrolysis. In this way patentees, licensees, and "outsiders" were kept busy in the matter of experiment for some considerable time; but in the long run, with one or two exceptions, the patentees and the holders of licenses got the best of the tussle until, and, indeed, long after, the patents became void by lapse of time.

At the period referred to the preparation of silver baths for electroplating purposes, even in the hands of persons who had deposited the metal on a fairly large scale, was far from being satisfactory, and the trade complaints of "stripping" and other defects were met by a stereotyped reply that "the solutions had got out of order." In many cases those who made up the silver baths possessed but little knowledge of electro-deposition, and were quite ignorant of the chemical principles involved in the art, and the employers had frequently to rely upon the clumsy manipulations of unscientific dabblers, and to suffer the loss and disappointment which each failure necessarily entailed. Discharged workmen—or rather employés, for the terms are not always synonymous—whose knowledge of electro-deposition had been gleaned by the odious system of "prying" into their employer's workshop, or by snatching a sneaking insight into his private note-book, frequently had the audacity to undertake the management of a plating-room, whereas, in many instances, their proper quarters would have been more suitably found within the boundary walls of one of Her Majesty's gaols. As time progressed, however, the beautiful art of electro-silvering, and its cognate arts, electro-gilding and electrotyping, received the attention of scientific observers in this and other countries, and the intelligent practical man soon found that the art, being a purely chemical one, could be more satisfactorily pursued, and difficulties more easily overcome, when a little chemical knowledge was acquired by the operator than when he relied solely upon the "rule o' thumb" system, which had hitherto been his guide.

In undertaking a series of experiments on the electrolysis of silver salts, I purposed, as far as possible, to travel over new ground—that is to say, I desired to ascertain the behaviour, under electrolysis, of various salts of silver not commonly manipulated by the practical operator, and also place under consideration certain silver salts which may possibly be unknown to him so far as regards their electrolytic behaviour. I may further add that in many of the experiments referred to I was desirous of ascertaining whether it would be possible to obtain a useful silver bath without employing the customary solvent, cyanide of potassium. My object in turning attention in this direction was to find out, if practicable, a salt of silver, a solution of which could be used for heavy plating—that is, for depositing thick coatings of silver from liquids prepared without the use of potassium cyanide. An endeavour was also made to obtain a silver bath in which an adherent coating of this metal could be deposited upon iron or steel, and also upon zinc. The experiments were conducted with the current from a modified Daniell battery, as described in former papers, one cell in most instances being sufficient, and in some cases the current was reduced by interposing in the circuit a very thin iron wire. The cathode consisted of plates of polished brass, 3in. by 1in., well scoured each time before using, with finely-powdered bathbrick moistened with water. To each of these plates a copper wire was attached by soldering. The anode employed was, of course, a plate of pure silver. Previous to preparing the various solutions, a quantity of silver carbonate was formed, and this was kept in a moist state in the dark until required for use.

1. *Nitro-Sulphate of Silver by Electrolysis.*—In this experiment an attempt was made to obtain a reguline film of silver from a very weak solution of nitric and sulphuric acids with the aid of a very feeble current. For this purpose four parts of each, nitric and sulphuric acid, were added to 1,000 parts of distilled water, and one Daniell cell, with a length of very fine iron wire interposed between the positive pole and the anode. Under these conditions a cleaned brass plate, being immersed in the solution, received a deposit of silver of a yellowish-brown colour in a few seconds. On rubbing the film with the finger the yellow coating disappeared, but a white film of silver showed upon the surface of the plate. The yellow deposit was doubtless metallic silver in a highly-comminuted condition. The bath was next still further weakened by the addition of 500 parts more distilled water, when the subsequent deposit upon a fresh plate still assumed the yellowish-brown colour after a few moments' immersion, but the film, however, firmly adhered to the plate; when this was removed by scouring, white metal, as before, appeared on the brass surface. An attempt was next made to check the formation of the yellow non-reguline film by adding to the bath, in small quantities at a time, a solution of nitrate of ammonia. The addition of the ammonia salt at first appeared to present some advantage in this direction; after a few minutes, however, the yellow film reappeared, and no modification of the solution by dilution or otherwise, or of the current density, would secure a perfectly reguline deposit of the metal.

2. *Acetate of Silver.*—A bath was prepared by digesting recently precipitated and moist carbonate of silver in strong acetic acid, heat being applied after a time to facilitate the solution of the carbonate. Distilled water was then added to the strong liquid, which was afterwards filtered for use. With the current from a single Daniell, a perfectly black film deposited upon a brass plate immediately after immersion. The solution was then considerably diluted with water, the anode surface reduced, and a freshly-prepared plate immersed, but even under these altered conditions the metal deposited in a black film, beneath which, however, was a perfectly white film of silver.

3. *Acetates of Silver and Ammonia.*—To the above solution was next added a solution of acetate of ammonia, when for a moment deposition appeared to proceed more favourably; in less than a minute, however, the film became dark-coloured and non-adherent, but on removing the loose deposit with the finger the underlying film appeared of the characteristic whiteness.

4. *Acetate of Silver by Electrolysis.*—A weak solution of acetic acid was first prepared, in which was placed a silver anode connected to two Daniells in series; no evidence of electrolytic action being observable in five minutes, three, four, and five cells, respectively, were tried, but it was not until the current from the latter group was applied that any perceptible action occurred, when the brass cathode gradually became coated with silver. After about a quarter of an hour it was found that a copious spongy deposit of silver had formed on this electrode, which, approaching, and eventually touching the anode, short-circuited the current. The plates, at the commencement of the experiment, were placed at a distance of about 1in. apart. The solution was next further diluted with water, the resistance of the fine wire again introduced, but under no circumstances could a genuine coating of reguline metal be obtained. Acetate of ammonia was again tried with the solution, but though this addition at first appeared to improve the character of the deposit, non-reguline metal eventually formed upon the film first deposited, and the solution had therefore to be abandoned.

5. *Citrate of Silver.*—To form a solution bath of this salt moist carbonate of silver was digested in a strong warm solution of citric acid, and the resulting solution, after

filtration, was diluted with distilled water. The current from one Daniell cell was used, when, as in the former case, a black deposit appeared on the cathode almost immediately after immersion. The solution was still further diluted from time to time, but it was not until the bath had become considerably weakened that an approach to a favourable deposit was obtained; and, indeed, this somewhat hopeful condition of affairs soon gave place to the inevitable reappearance of non-reguline metal. Even with the current density greatly reduced, a very small surface of anode only immersed in the solution, and copious dilutions of the liquid, the ultimate deposits invariably assumed the spongy and non-adherent form.

6. *Citrates of Silver and Ammonia.*—A quantity of citrate of ammonia was next added to the foregoing bath and electrolysed under the same conditions. The deposition now took place somewhat more tardily, and a fairly good film at first appeared. In less than one minute, however, the plate assumed a dull appearance, and on rubbing the deposit with the finger it at once became dislodged, and rested on the finger in the form of a grey powder. No further modifications yielded a perfectly reguline deposit, so the liquid was set aside.

7. *Citrate of Silver by Electrolysis.*—In all the experiments with silver salts prepared from the vegetable and other weak acids, it was determined to ascertain what solvent action they were capable of exerting upon the silver anode under the influence of the current. In the present trial, therefore, a rather weak solution of citric acid was first prepared as the electrolyte, in which the anode was placed, and the current from two Daniells in series allowed to pass, a brass plate cathode being used as before. The electrodes were placed about 1in. apart, and in a few moments a black spongy deposit formed upon the brass plate, showing that the acid had attacked the silver anode with some energy. The solution, however, like the preceding, failed to yield other than spongy metal.

8. *Tartrate of Silver.*—In a warm and strong solution of tartaric acid was digested, with constant agitation, a quantity of moist carbonate of silver, and after filtration and considerable dilution, the liquid was electrolysed with the current from a single Daniell, but the resulting deposits upon the cathode were almost precisely similar to those obtained from the citrate. A solution of tartrate of ammonia added to the bath, though presenting some advantages at first, failed to secure an uniform coating of reguline metal.

9. *Tartrate of Silver by Electrolysis.*—In a rather strong solution of tartaric acid, electrolysed with the current from two Daniells in series, the silver anode became freely acted upon, and spongy metal appeared upon a brass cathode very shortly after the immersion of the plates. In other respects this solvent did not yield satisfactory results.

10. *Oxalate of Silver.*—A solution of this salt, prepared by digesting moist carbonate of silver in a strong hot solution of oxalic acid, was tried with the current from one to five cells in succession, but no deposit was obtained until the latter series of cells had been connected, and even with this current only a very slight film of a darkish colour was obtained. A strong solution of oxalate of ammonia was then added to the bath, but this failed to improve the condition of the bath. An attempt to obtain a solution of the oxalate by electrolysis was not successful, since this acid appears to have no solvent action on the anode.

11. *Lactate of Silver.*—To form this solution, moist carbonate of silver was digested in a strong and warm solution of lactic acid, and the solution, after being filtered, was tried with the current from a single Daniell, when deposition was found to take place very slowly; the deposited metal, however, was of a very indifferent colour, and non-reguline or spongy metal ultimately formed on the plate. A solution of lactate of ammonia was then added to the bath, when a thin white film of silver slowly formed on the plate, but was found to be absolutely non-adherent, and was easily rubbed off the plate with the finger.

12. *Borate of Silver.*—A bath was formed as before by digesting moist carbonate of silver in a strong hot solution of boracic acid, the solution being afterwards filtered and diluted with distilled water. With the current from one cell, a white film of silver was at first obtained upon a brass plate, but this was soon succeeded by a deposit of black non-reguline metal. A solution of borate of ammonia was next added to the bath, when the subsequent deposits appeared somewhat more readily disposed to keep in the reguline condition, and still better results were obtained when the solution was further diluted with water. Ultimately, however, the film assumed a less favourable aspect, and non-reguline metal became deposited upon the first coating of reguline metal.

(To be continued.)

THE LATE W. LANT CARPENTER.

We regret to have to record the death of Mr. W. Lant Carpenter, especially as his work was connected with the education of the younger generation of electrical engineers. The school opened by Mr. Lundy, and continued by Mrs. Lundy, has of late years been under the management of Mr. Carpenter and his colleague, Mr. Drugman. That the school has been successful under this management shows that the broad views of the managers were in accord with the requirements of the day. Owing to illness, Mr. Carpenter has for many months taken no part in the management, so that the work of the school will not be interfered with by his untimely decease. The late Mr. Carpenter and the present writer had many and long discussions upon the alterations that were introduced into the establishment up to the time when the present staff was organised, and while, as might be expected, not in agreement upon all points, there existed no difference of opinion upon the main questions under consideration. We found at all times that Mr. Carpenter not only was willing to listen to suggestions, but courted them, seeking arguments for and against till thoroughly satisfied in his own mind that his conclusion was the best. To say that Mr. Lant Carpenter was the son of his father is saying a good deal. Education owes much to the work of these two gentlemen. Dr. W. B. Carpenter reigned long at London University; he was enthusiastic about deep-sea sounding and research, and his son was as enthusiastic in his work connected with university extension.

Mr. W. Lant Carpenter was born in 1841, educated at University College School and at University College. He took a bachelor's degree in science at the London University. The early part of his working life was spent in Bristol as partner in a manufacturing business, but even here his special bent asserted itself, and he was an active promoter of the movement that led to the foundation of University College, Bristol, of which another old friend, Dr. Langton, was registrar. Mr. Carpenter sat on the council for some time as the nominee of the Vice-Chancellor of London University. He took an active part in the Bristol meeting of the British Association in 1875, being one of the local secretaries. He was in charge of the chemical and part of the physical investigations of the deep-sea explorations of H.M.S. "Porcupine" of 1869 and 1870, his report on which was printed in the *Proceedings* of the Royal Society. Having determined to devote himself entirely to scientific pursuits, he removed to London in 1881, and was employed by the Gilchrist Educational Trust in delivering popular lectures to very large artisan audiences upon experimental physics, and mainly upon electricity. One set of such courses, intended especially as a popular exposition of the doctrine of the conservation of energy, was published in book form under the title of "Energy in Nature." It was very favourably received on both sides of the Atlantic, and speedily reached a second edition. His lecture on the "Life and Work of Sir Wm. Siemens," published in the *Gentleman's Magazine*, attracted much attention. He has also lectured to large audiences in America, Australia, and New Zealand. He took an active part in the Universities Lecture Scheme. His death took place on the 23rd of December at his residence, at Harlesden. At the time of his death he was in the fiftieth year of his age.

UNDERGROUND MAINS.—II.

THE CROMPTON SYSTEM.

The system of underground mains used by Messrs. Crompton and Co., Limited, is that of bare strips of solid copper stretched upon glass insulators in an underground culvert, and strained in air from point to point by means of specially constructed straining apparatus. The Crompton system is in use for the low pressure distribution of electricity for direct currents, with or without the use of accumulators, and is principally used upon the three-wire system of mains, though it is also applicable where desired for ordinary parallel distribution. The system has been in successful operation for about four years, and besides the original Crompton central station at Kensington and Knightsbridge, where it was first developed, and where over 12 miles of mains are now laid, it is in use or is being laid for the Notting Hill Electric Light Company, the Westminster Electric Company, at Northampton, at Birmingham, and also in France. Nearly 100 miles of mains in all are now in use or are being laid.

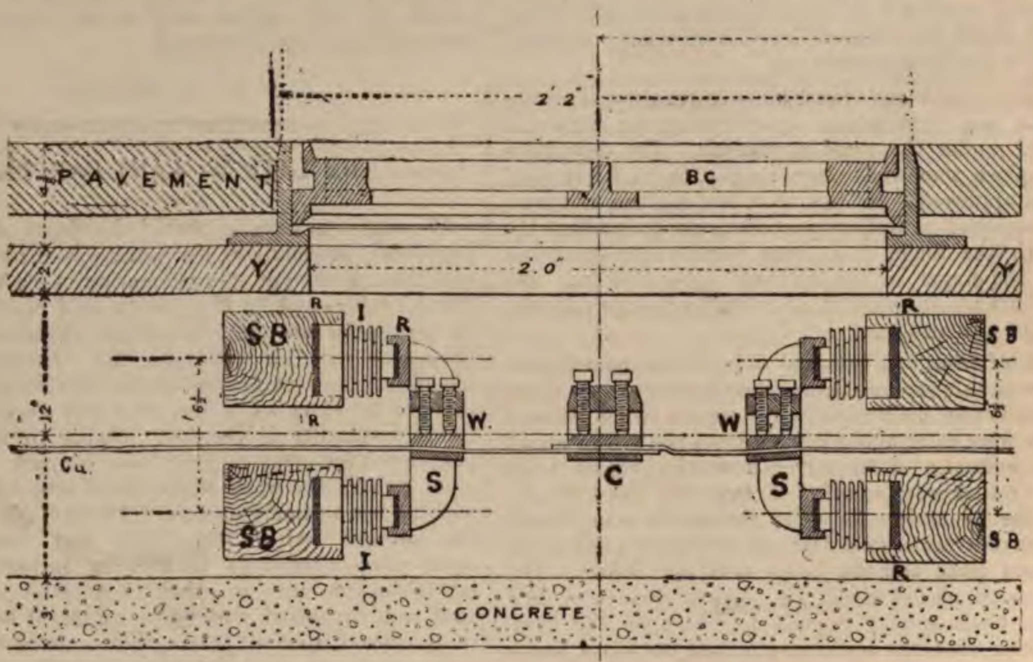

FIG. 1.—Straining Box, showing joint of two copper strips.

In principle, the system may be considered as a return to the ordinary methods of running telegraph wires, but applied to heavy copper mains, and underground. Mains for electric light were originally heavily insulated, afterwards cased in lead, then passed through protecting iron pipes, and finally run in conduits or culverts. To make these culverts such that bare conductors of sufficient thickness could be strained in air—which, after all, is the best as well as the cheapest insulator—thus doing away with costly insulation, has been the aim in the Crompton system, and, in point of fact, this system is one of the earliest attempts at a practical solution of the question of underground distribution on a large scale, and its success has given a great impetus to the planning of central distributing systems.

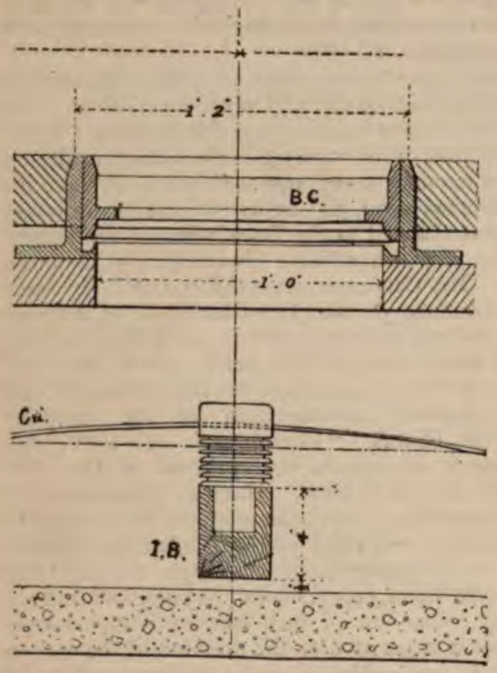

FIG. 2.—Insulator Box—Longitudinal Section.

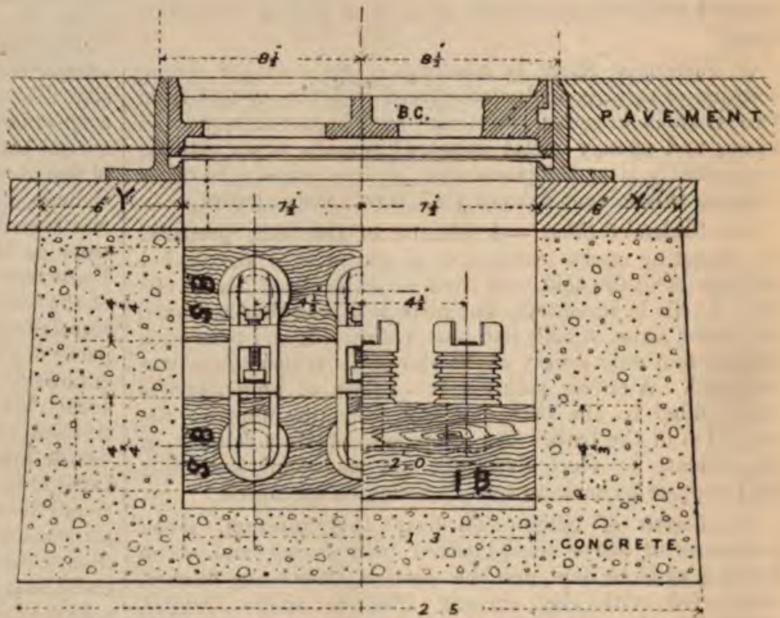

FIG. 3.—Section of Culvert—3-wire mains only.

The development of the Crompton system of electric mains has been, roughly speaking, through the following stages: First, a solid square bar was carried upon a wheel insulator fastened sideways in a culvert, changed afterwards to an upright cup insulator having a slot in its head, carrying first a bar, then modified to a bundle of wires, and again modified to a set of strips placed sideways on their edges. The alteration of the position of the strips, placed next on the flat, brought the method to one much as now in use, its later development being mostly in the mechanical form and the practical method of placing the insulators, and in the system of straining. At first this straining was brought about by the use of a right and left handed screw on the solid copper bars, which drew the lengths together; the alteration was soon made of having each length strained separately, and connected together by a by-pass of solid copper. As at present used, each length of copper strip is separately strained, and the overlapping ends are then tightly screwed together by a screw connecting piece, the strain being taken by specially constructed straining-pieces in the manner hereafter described.

The mains on the Crompton system are made to three standard sizes. These represent (1) the usual three-wire distributing main; (2) the distributing main with one pair of feeders; and (3) the distributing main with two pair of feeders. It is seldom that other sizes than these are necessary; if such cases arise, two separate culverts would be run for the distance required.

The principle of the three-wire system of distribution is now sufficiently well known. With a total pressure of say 210 volts between the outside wires, the pressure between the inner and either of the outer wires is 105 volts. The wires to the houses are connected alternately in such a manner that the number of lamps on one side balances that on the other, so that no current (or only the slight difference between the two halves) is flowing through the centre wire. To keep the pressure the same over all parts of the circuit, feeder mains going to certain determined points where the demand is heaviest, are connected direct from the source of supply, and thus the potential is kept constant.

(*To be continued.*)

LOW-SPEED MULTIPOLAR DYNAMOS AND MOTORS FOR CONTINUOUS CURRENTS.

BY FRANK A. PERRET.

The many practical advantages of a lower rate of speed in dynamo-electric machinery have long been recognised, yet until recently few attempts have been made to secure it. The widespread use of the electric motor has, however, rendered low speed a feature of great importance, in that it so greatly simplifies the application of the machine to all classes of work, in most cases obviating the necessity of countershafting or similar speed-reducing mechanism.

The writer is aware of a prevailing opinion that serious difficulties are encountered in the attempts to manufacture this class of machines on a commercial basis, but believing the difficulties to be surmountable he devoted several years to a careful study of the subject, with the result that he designed a type of machine in which he believes the desired end is attained without the introduction of any element of danger or the sacrifice of a single feature essential to a thoroughly practical machine.

In the light of this experience it is proposed to consider briefly some of the principles which govern the action of multipolar machines, and to demonstrate that the obstacles which have heretofore stood in the way of low speed may be, and have been, overcome.

The prime function of an armature conductor is the generation of an E.M.F., the value of which is proportionate to the number of magnetic lines of force cut by it in a given time. Now, the number of lines cut per second is dependent upon two factors, (1) the total number of lines of force in the magnetic circuit, and (2) the number of times they are cut per second. As our aim is to generate a given E.M.F. at a lower speed than is usual, it is evident that the quantities in either or both of the above factors must be increased. In the case of the first we are limited by the saturation point of iron which prevents our indefinitely increasing the strength of the magnetic circuit without adding abnormally to the weight and size of the machine, and even were it possible to do this, an increased exciting current would be required, which would detract directly from the total efficiency. We turn then to the second factor and, paradoxical as it appears at first, it is here we find the solution of the problem. How are we to cause an armature conductor to cut a given number of lines of force a greater number of times per second without increasing the speed? In the ordinary two-pole machine the armature conductor crosses the magnetic circuit and cuts all the lines of force twice during a complete revolution—viz., where they enter the armature core at one pole and where they leave it at the other. Now, if we so dispose the magnetic circuit as to cause the lines of force to enter the armature core at one point, to leave it at another, to enter it again at a third point and to leave it at a fourth, it is obvious that the conductor will cut all the lines at four points in each revolution, and that it will therefore generate the same E.M.F. at one-half the original speed. If we increase the number of poles to six, we shall obtain the same effect at one-third the speed, etc. This, then, is the principle of construction by which we secure low speed.

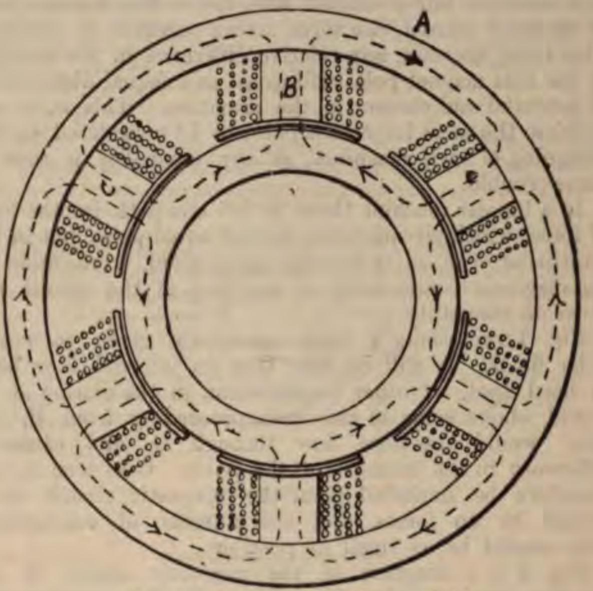

FIG. 1.—Ordinary Multipolar Field.

It should be noted that we do not increase the number of lines of force in the magnetic circuit, we do not add to the turns of wire in series on the armature, we do not increase the amount of either copper or iron in the entire machine, but we simply cause the armature conductor to cross the magnetic circuit as often in one revolution as it ordinarily does in two or three revolutions, as the case may be. The writer wishes to emphasise these points as there seems to be some misunderstanding in regard to them. We do not wind an armature to run slowly, but we design the machine for low speed. The resistance of our armature is no higher than that of a high-speed machine of the same power, its current capacity is not reduced; in fact, as we shall see later, it is increased. The efficiency is no lower, the regulation no less perfect, and the weight and bulk no

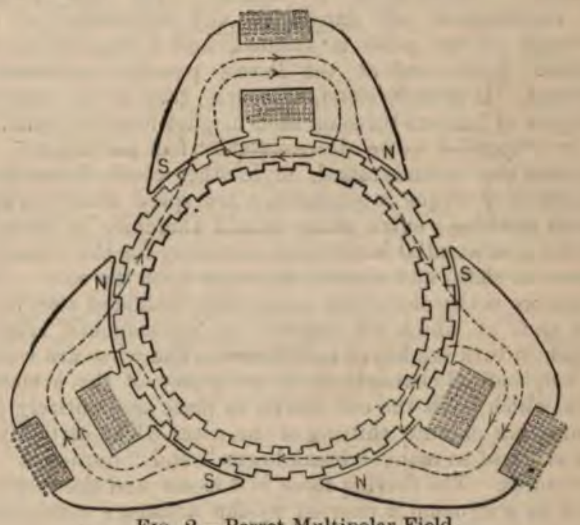

FIG. 2.—Perret Multipolar Field.

greater. We see, then, that in theory the multipolar machine is perfect; consequently, if any difficulties have been encountered in its practical operation they must be due to some faults of construction, to a consideration of which the attention of the reader is now invited.

If we take as an example a motor having a six-pole field, and imagine the same in action, we see that the distribution of potential is such as to form the equivalent of three ordinary armature windings on the one ring and connected to the commutator, which has three times as many segments as that of a two-pole machine. Each of these windings—*i.e.*, the wire lying under one pair of poles—has exactly the same number of turns as an armature of a two-pole machine, but of smaller wire, and carries but one-third of the total current, the three acting together in multiple. This being the case, any relative difference in the strength of the field magnet poles will cause an unequal distribution of potential and current in the armature. This is, in my opinion, the most important point to be considered in the designing of such machines, as any inequality is sure to cause trouble.

In a bipolar machine there is but one path for the lines of force, which circumstance ensures equal poles, but in the multipolar type, as ordinarily constructed, a variation in the magnetic conductivity of any part of the circuit will cause an inequality.

Fig. 1 represents a form commonly given to multipolar fields. It will be seen that an internal blow-hole, or hard spot, or other imperfection in the casting at A, would choke some of the lines proceeding from B, and they would therefore flow through C, and cause a difference in the strength of the poles. Cast iron should therefore be excluded from the magnetic circuit, there should be no joints, and the number of magnetising coils should be as small as possible.

Fig. 2 is a diagram of the magnetic circuit of the machine designed by the writer. In this construction there are but three magnets, each being isolated magnetically from the others excepting through the medium of the armature core, and completely isolated from the framework of the machine. They are formed of plates of soft sheet iron, which are punched to the required shape and strung together on non-magnetic bolts by which they are secured to their supports. A single magnetising coil forms two salient poles, and as each magnet is built of a large number of plates a uniform magnetic conductivity is secured. By this method of construction all danger of any inequality in the strength of the poles is avoided, and a magnetic circuit without joints and of the lowest possible resistance is secured. It is understood, of course, that in all cases the number of ampere-turns on each magnet must be equal.

In proportion as we decrease the "feet per minute" we increase the "pounds raised," or, in other words, the mechanical effort or torque is greater in a low speed than in a high speed machine; extra pains should therefore be taken to secure a substantial mechanical mounting for the armature upon the shaft, and also for the wires upon the core. The armature is therefore built up on eight insulated steel bolts, the ends of which are secured to non-magnetic spiders, which in turn are keyed to the shaft. The wires are wound in longitudinal channels on the periphery of the armature core, which holds the coil rigidly in place and entirely prevents that minute shifting of the wires which certainly is the cause of so many "breakdowns" and "burn-outs" in armatures. The driving force in a motor and the resisting force in a dynamo is exerted by the armature conductors, and we should always provide a positive mechanical connection between them and the core; friction does not suffer. The importance of this point is fully understood by Kapp, who writes: "In many machines the friction produced by the binding hoops is alone relied on to carry the wires through the field, but experience has shown this to be insufficient. Even if the wires are not bodily torn off the armature by the magnetic resistance of the field, they shift and work on the surface of the core; and it is only a question of time when the insulation will be destroyed, and the machine break down."

We have a choice of two methods of coupling the armature circuits together in multiple, one of which is by the use of six brushes distributed around the commutator 60deg. apart, three negative and three positive, and the other consists of a system of cross-connections in the armature or commutator, which connects those coils which are simultaneously undergoing the same induction; these in a six-pole machine are situated 120deg. apart. By this means a single pair of brushes suffices, and these bear on the commutator at points diametrically opposite, exactly as in a two-pole machine. This method is preferred when copper brushes are used, and I have in use a simple system of cross-connections at the back of the commutator, in which all danger of short-circuiting is avoided; but the carbon brush is so peculiarly adapted to the method just described that it forms one of the simplest and most reliable means of commutation that can be devised. The high resistance of the carbon brush, as ordinarily constructed, has prevented its universal adoption, but the construction of this machine permits the use of three pairs of brushes, each pair carrying but one-third of the total current, and the resistance is greatly reduced by reason of the increased contact surface.

In a two-pole machine the armature current is divided equally between two circuits, while that of a six-pole machine splits into six. This the writer considers in most cases an advantage, as the current-carrying capacity is increased by reason of the greater surface exposed to radiation, and the machine will consequently bear a greater overload without injury, while the wire is not so large as to be unmanageable. In many machines of the two-pole type a stranded armature conductor must be used, because a single wire would be too stiff, and would heat too much; in a multipolar machine these troubles are avoided.

A great deal has been said and written in respect to the difference of potential that should be allowed to exist between adjacent commutator segments, some writers having advanced erroneous opinions on this point to the disparagement of multipolar machines. One tells us that 10 volts should be the limit because "10 volts will just form an arc," while another puts the limit at 19 volts, and gives the same reason.

Now, an arc has to be started or "drawn," and the only time this can happen is when the brush connects two adjacent bars as they pass under it. But this only takes place at the so-called neutral points, where the difference of potential between adjacent bars is almost nothing. Theoretically, this difference of potential is simply the product of half the total current and the resistance of the coil connected to the two bars. We see, therefore, that we should not take for a basis of calculation the average difference of potential between adjacent bars, for the reason that the E.M.F. of each coil is continually varying from zero to maximum, and down to zero again. A very clear description of this action will be found in the fourth chapter of S. P. Thompson's "Dynamo Electric Machinery," together with the methods used in determining it, and I commend a perusal of this to the writers referred to.

In a machine wound for 220 volts and having 22 coils acting in series, we do not find a uniform difference of potential of 10 volts between adjacent commutator bars, but those coils which are passing the poles are generating 15 or 20 volts, while those in the neutral zone are generating practically nothing. In some of the most widely-used closed-coil machines in this country the average difference of potential between adjacent segments is far greater than the limits given by the above-mentioned writers. In one of these it is 27 volts, in another 50 volts, and in others it is still higher, yet these machines give no trouble whatever.

Let me not be understood to favour the use of a small number of commutator's sections, I simply wish to show that no one is limited to 10 or 19 volts average potential difference between adjacent bars.

In the machines of my own design which I have partially described, the number of sections in the commutator is 96, of which 16 act in series. At an E.M.F. of 220 volts they average, therefore, 13¾ volts each, and at 500 volts total E.M.F. they will average 31¼ volts.

As bearing upon some of the statements which I have made I present the following details of 10 and 20 h.p. machines, which fairly represent them all.

10-h.p. 220-volt motor.
  Speed, 600 revolutions per minute.
  Weight, 900lb.
  Resistance of armature, ·19 ohm.
  Resistance of shunt, 175 ohms.
20-h.p. 110-volt dynamo (compound).
  Speed, 600 revolutions per minute.
  Weight, 1,300lb.
  Resistance of armature, ·029 ohm.
  Resistance of shuut, 26 ohms.
  Resistance of series coil, ·007 ohm.

It will be seen that a low-speed multipolar machine is not necessarily a heavy one, but that, on the contrary, it may be made very light. The writer has recently built several 25-h.p. series wound motors, which weighed 1,300lb. each, and ran at a speed of 500 revolutions per minute. If one of these were so wound as to run at 1,000 revolutions per minute, it would develop 50 h.p., and weigh only 26lb. per horse-power. For traction purposes these motors are designed to run as slow as 450 revolutions per minute, and weigh about 70lb. per horse-power.

In regard to their practical operation, I will simply say that the first machines which were constructed a year ago have been in constant and satisfactory use ever since, and they have proved themselves to be in every respect the equals of the high-speed machine.—*Electrical Engineer* (New York).

INDUCTANCE AND ITS PROPOSED UNIT THE HENRY.[*]

BY A. E. KENNELLY.

Perhaps the greatest discovery of Faraday's long career of scientific research was that of electromagnetic induction in the year 1831, when he first brought to light the influence exerted by a magnet or a current upon surrounding matter when subjected to a change of magnetic potential. Oersted had shown that a conductor carrying a current exercised electromagnetic influence at a distance, and Ampère had enunciated those simple and beautiful laws this influence is admitted to obey, but Faraday's discovery was a great step—it revealed the action of magnetic force in apparently empty space; it inaugurated that deeper insight into the mechanism, still only dimly guessed, which connects matter with all other matter in space, and it invested the all-pervading ether with a dignity and power that in the hands of many great men since his time has probably paved the way for our future comprehension of magnetism, gravitation, and radiant energy, while making the hypothesis of action at a distance a mere mathematical conception and process of thought.

The development of this discovery of electromagnetic induction has practically created electrical engineering, for it is to machinery operating by electromagnetic induction that we owe nearly every branch of electrical industry, except, perhaps, telegraphy, the forerunner of all; and the condition of modern electrical engineering is such that the units and nomenclature relating to steady currents and permanent magnets is insufficient for practical requirements, and the conditions developed by variable currents and magnets demand the establishment of engineering practical units for the purposes of convenience in expression and computation.

Foremost among these required units is that of inductance, or, as it is commonly called, the coefficient of induction. This induction is a property fully as essential to every electric conducting circuit as resistance and electrostatic capacity, and the inductance of a circuit when conveying variable currents is often a far more important factor in regulating the flow than the ohmic resistance. In fact, we know that Ohm's law does not apply to a circuit so long as the current is unsteady, unless the inductance of the circuit or the counter E.M.F. it involves be introduced into the expression.

In conformity with the conventional and so-called absolute units of electromagnetism, an inductance is a length, and theoretically can always be computed from the geometrical relations of a circuit; that is to say, if the distance of each point from all other points of a circuit be measured, or inferred, in inches or centimetres, the inductance of the circuit will be some definite number of inches or centimetres, capable of being determined by a possible if not a convenient process of summation. If the circuit, however, be associated with iron or other magnetisable matter, then the magnetic permeability of the environment will enter the terms of summation as a multiplier. In the absolute centimetre-gramme-second system of units, inductance will be necessarily expressed in centimetres, and the centimetre is thus the natural scientific unit, although unsuited to the requirements of electrical engineering.

It may be well to notice that inductance is only conventionally, and, perhaps, not essentially, a length. Prof. Rücker has pointed out that the multiplication of the permeability factor with the length factor is always tacitly, if not expressly involved, even when the circuit considered is far from magnetisable matter in the ordinary sense—that is to say, when residing in a medium of unit permeability—and, therefore, the nature of inductance is not merely length, but length multiplied by permeability, while physics has not yet decided whether permeability is the simple numerical factor at present assumed, or a function of length, mass, and time. Until this question is settled, the real nature of inductance must be considered as doubtful, and the fact that inductance will probably, in any event, be always measured by lengths is no more validly an argument as to its nature, than the usual determination of a body's mass by the earth's gravitational force upon it is an argument that mass is a force. However, the question is one of theory only, and does not affect the consideration of the practical unit.

As has been pointed out by Dr. Sumpner, there are no less than three ways of defining the inductance of a circuit, or a portion of a circuit, and the three definitions are equivalent when the permeability of the magnetic medium is unity, but are not generally equivalent in the opposite event, being then only related in a definite manner by the magnetic properties of the medium. In other words, the inductance of a hollow solenoid of copper wire, placed in a vacuum and far from all iron, has the same numerical value in each of the three definitions, but if an iron core be inserted in it, its inductance will depend upon the definition selected, and will only be capable of interpretation from its value in one to its values in the others, by taking into account the characteristic permeability curve of the iron, and the conditions of the measurement.

The inductance of a circuit, or portion of a circuit, is then the ratio between the total induction through it to the current producing it. Thus taking a simple helix of five turns carrying a current of two units, and assuming that 1,000 lines of force[*] passed through the central turn, of which, owing to leakage, only 900 thread the next adjacent on each side, and again only 800 through the end turns, there would be 800+900+1,000+900+800, or 4,400 linkages of lines with the wire, and this being with two units of current there would be 2,200 linkages with unit current, and consequently the self-inductance of the helix would be 2,200 centimetres. Fig. 1.

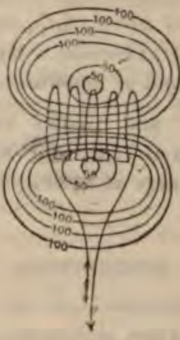

FIG. 1.

The fact that such helices are used in galvanometers, and that the magnetic force at any point with them is admitted to be proportional to the strength of the traversing current, renders it evident that had the current in this case been one unit, 2,200 lines linked with the coil would actually have been produced. Supposing, however, that the helix had been wound upon an iron core, the total number of linkages with the same two units of current would have been greatly increased, perhaps twentyfold or to 88,000, and the inductance then by the same rule would be 44,000. In this case one unit of current would not in all probability reduce the number of linkages to 44,000, the exact number would depend upon the characteristic curve of the iron core and the degree of saturation, so that it would now be necessary to state the conditions of the measurement along with the result in order to convey a clear and definite meaning.

It appears anomalous at first sight to state the above inductances in centimetres when they are derived from the number of lines of force, but it is to be remembered that the total number of linkages is divided in each case not by a mere numeric, but by a current, and this quotient can be proved to be a length in the existing system of dimensions.

In the same way the mutual inductance of two conductors is the ratio of the total induction through one of them to the strength of current in the other producing it. Suppose two coils of copper wire to be held in free space far from iron, and let one of them be traversed by a steady current of, say, four units. Of all the lines of force issuing from this coil, suppose 500 pass through the other coil. For simplicity, imagine the second or recipient coil to be composed of eight turns so disposed that the 500 lines pass through all in succession. There will then be 4,000 linkages of lines with that coil, and the mutual inductance of the two will be 4,000 ÷ 4 or 1,000 centimetres. It is interesting to notice that the same result would be reached if the second coil had the current and the linkages were counted in the first, the pair being mutually conjugate in this respect, provided they reside in a medium of constant permeability.

(*To be continued.*)

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[*] A paper read at the fifty-second meeting of the American Institute of Electrical Engineers.

[*] The term line of force here is used in the sense of a line of induction; the distinction being necessary when the lines pass through iron.

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1891.

MAY IT BE TO EACH READER A HAPPY AND PROSPEROUS YEAR.

It has been our custom in the first issues of the year to obtain from various firms and companies interested in the industry a *résumé* of their work during the year, and an expression of opinion as to future prospects. That many of the names appear year after year is but a proof of successful enterprise and the survival of the fittest. Here and there a firm as it increases in age increases in conservatism, and while in earlier days, with the blood coursing more swiftly through its veins, its business instincts were stronger, and more eagerness was shown to make a name and establish a record, it, as it grows older, seems content to linger out a respectable life. Such firms exist, but most emphatically they will be outstripped in the race unless they think less of what they have done and more of what they should do. In business, as elsewhere, he who ceases to be aggressive ceases to be progressive. The time has long since passed when business came in because a sign was hung out. New firms are rapidly springing up, determined to have their share of business, and sometimes leaving the beaten path of success too far behind in their eagerness to snatch work from competitors. Still, on the whole, the tendency is upwards as regards the character of the work done. Perhaps some readers may demur to this conclusion, and doubt the accuracy with which insurance companies can gauge this kind of work. They are welcome to their opinions. We think otherwise, and put a question as to character of work now done compared with that done in past years to a gentleman who probably sees more electrical work than any other man living in these isles, and the answer was: "The work now done is distinctly better."

The danger to electrical work is twofold—bad workmanship, and what old women in Buckinghamshire call "scrimping." In previous years we have had our say as regards bad workmanship, and now pass it by in the hope that the improvement may continue, but the "scrimping" must have a word. The fear of Mr. Hartnell is in our eyes, and no doubt he will declaim with piquancy and pungency at the ignorance of technical writers, when we say it is a mistake, and a great mistake, to be too niggardly with copper anywhere. It is all very well to answer that calculations have shown this or that section to be sufficient to carry the proposed current. Calculations prove a lot of things that experience says are nonsense, and in this age of calculations they are too often made the vehicle of schedules of prices which allow no margin for contingencies or for factor of safety. The young firm especially, whose experience has yet to be bought, tenders upon calculations which leave no margins, and no one of greater experience is surprised when they have to pay for their wisdom. Take it as scientifically doubtful, but take it as a matter of fact, that deterioration of work and material does take place, and that if satisfactory and permanent work is to be done such deterioration must be allowed for. Niggardliness with copper in wires means also greater cost of and loss in working; in machines means failure, trouble, and any amount of disputes.

When we come to consider the business problems that await solution to-day, we find that they are very similar to those awaiting solution a year ago. Men are, however, beginning to see that some of them are insolvable. The distribution from central stations, what shall it be—high pressure, low pressure, by alternate currents and transformers, or by continuous currents and batteries, shall the three-wire or n-wire of any specific system of distribution be adopted? The answer is, or should be, that each system has its place, and one will be preferred here, and another there, according to surrounding circumstances. By the way, is there any reason why "transformers" or "converters" should have a specific name? They are alternators in every sense of the word. The generating alternator at the central stations transforms upwards. The converter is an alternator transforming downwards. Where is the insuperable difficulty of building generating alternators on the same lines as transformers? Faraday gave us two types of alternators; and even with all the eulogies bestowed upon him, his devices have never been sufficiently widely recognised as actual typical machines. Faraday also gave us the means to construct a workable theory of a simple character, which has since been so overladen with high-sounding terms and unnecessary mathematical interpolations as to frighten students. Any mechanical engineer with an ordinary education may in a short time learn all that is necessary to enable him to construct dynamos which have as great a commercial efficiency as any dynamo ever constructed by the most learned professor. We do not for a moment disparage the investigation of minute points; but so far as dynamo building is concerned these minute points are almost valueless. We want thoroughly sound mechanical education first, and then the electrical. This is what parents do not understand, and what it seems to be the aim of some people to hide. Nine-tenths of electrical work in lighting and power distribution is purely mechanical engineering, and if a man wants to succeed he had better know less about hysteresis and more about mechanics. Electricians are not so much wanted in the world as are electrical engineers. The latter are wanted, badly wanted, and the future lookout for them is particularly healthy. Once more, then, we urge young men not to be frightened away because the subject seems so transcendental. It is not. Put on the slops, go through the shops, and you will find plenty of work. On the other hand, if you are afraid of a little clean dirt, and think overmuch of pretty instruments and pretty calculations, the field is full, and you are not wanted in it. We are well aware that our standpoint is contrary to that of many well-meaning but ill-informed people; it is the result of experience. All men can't be gentlemen and wear kid gloves because they have heard of "Ohm's law," and have read extensively the electrical literature of to-day. Thomson, Thompson, Ewing, Forbes, Kapp, Hopkinson, Lodge, and a dozen others have done and are doing grand work, but where there is room for one of these there is necessarily room for 500 of a different class. Many, too, of the latter make bigger incomes than the former.

To return to the question of distribution. Last year we said all eyes were turned towards Deptford. What was said then may be said again, and the more so because some of the gas journals, with their more than bitter antagonism and utter disregard of facts, are trying to damn the work of Mr. Ferranti. Our sympathies have always been in favour of continuous currents, because we think "power" more than "light" must become the cry, and the supply of both should be equally simple. We are told that alternate-current motors are ready whenever they are wanted. If that is so—and there is no inherent reason why it should not be so—one objection to alternate currents is gone. But as regards Deptford, the system has not been tried. The time to stop work passed as soon as work commenced. The old axiom that "faint heart never won fair lady" should be the maxim of the London Electric. They must proceed, and they must succeed. Theirs is not the first company that has passed through a slough of despond, and, goodness knows, their slough at the moment must be bitter enough. Beset by virulent enemies, who stick at no mean trick to undermine the company, the friends who should support them are very lukewarm in their praise, and, like politicians, sit upon the fence to watch which way the cat jumps, or the better to give an unseen push downwards. It is the way of the world —kick a man if you think he is down.

It has been said that our advocacy is from interested motives. To this we might reply in the language of Bret Harte. Most of our readers have read his poem on number "Seventy-nine"; if not, the best thing they can do is to read it at once, and picture us as "79" and Mr. Ferranti as the other party. To us Mr. Ferranti and the London Electric are in the position of men who have undertaken, after due consideration, engineering work of the utmost importance. They have to encounter difficulties in the progress of the work, as all thoughtful men must have expected. They have met them, met them bravely, and over and over again have encountered them successfully. A chapter of accidents had also to be met, and for the moment floored them. That does not spell failure, for as yet the system has not been on trial. It does not mean, however, that the sympathies of fellow-workers ought to be withheld, unless from the very first there were known scientific or practical reasons pointing to the impossibility of success. We challenge any competent man to support any reason of this kind. We say there exists no such reason. In a word, Mr. Ferranti has had our consistent support because we can see no reason why his proposed high-pressure distribution should not be successful.

It may be well here to refer to another matter which is important—viz., Stock Exchange quotations. A careful examination of such quotations will show that they are not real indications of the status of a company. They may be indications of how well certain wire-pullers can engineer and finance matters to their own benefit. We are quite ready to prove that certain quotations have no solidity, and it is almost as certain as anything mundane can be that some shares quoted at higher values are not really so valuable as those quoted at lower rates. Time will prove whether our instincts are correct, and we fancy will, by a turn of the wheel, show shareholders that "finance" is not in the long run as good as "work." Let us venture to prophesy. Old Father Brush has had a chequered career, but its shares are now quoted at too low a price, and twelvemonths hence investors will wonder why on earth they could not see it. But, as we say, the quotations are merely financial; few transactions take place. Those who hold some of the lower quoted shares are quite prepared to hold and to wait the proper time. In several cases they are certain to reap a rich reward. Of course our surmise contains the proviso that business continues to be conducted upon the same keen lines as at present. Men there are connected with some of the more prominent companies who could not well be matched even with Shakespeare's witches to mingle Greek, Scotchman, and American in the best proportions to ensure perfection in 'cuteness. It is these men who are gradually restoring confidence in the investing world, though they have a hard task to counteract the Machiavellian customs of the mere gambling promoter and speculator.

Two questions we have recently discussed will become more and more pressing. These relate to fluctuations of pressure in supply from central stations, and to actual rather than nominal candle-power supplied. We have recently seen a gas company fined for not supplying gas up to standard. It is certain that consumers of electrical energy will not be placed in a worse position than the consumers of gas. Pressure ought never to fluctuate more than 1 per cent., and lamps ought never to give a less light than 1 per cent. below the candle-power they are supplied and supposed to give. These are rigid conditions, my masters, and you say they cannot be complied with. Why not? Engineers and millowners long ago came to the conclusion that the proper way to provide for the working of mill machinery is to have plenty of power. And how often we hear the remark that such and such a mill should have an electrical installation because there is plenty of waste power, so no cost in that direction would be involved. Whether is it easier to regulate pressure when you have it in plenty and to spare, or to regulate when it is calculated so closely that under ordinary circumstances no difficulty arises, only under extraordinary? Will suppliers of electricity have to learn what they ought to know already, and that is, Englishmen kick up a fearful row when the extraordinary times come, and you may do almost what you please in ordinary times?

The plan of systematically keeping the pressure at the minimum point allowed by Act of Parliament, when lamps to give normal candle-power require normal pressure, means dissatisfaction. The electric light is not installed to have less light than with gas, but rather, if not more, to have the same light under healthier conditions. You promise 8 or 16 candles and you give 6 or 12 candles. Is this the way to succeed in business? We trow not, and though luxury or fashion may put up with inconvenience for a time, the mutterings are beginning to be already loud and deep, and from quarters, too, that will not hesitate to strike and strike hard if not attended to. While suppliers must look to their production, lamp-makers have also their part to play in providing proper apparatus. Lamps deteriorate, and sometimes rapidly. It is not a question now, has a lamp lasted 11,000 or 14,000 hours, but how many hours will it give with normal pressure the candle-power it purports to give? At one time "lasting" was a lamp test. It is so no longer. We know that lamps can be made to last a thousand or more hours, but lamps are constructed to give light, and unless they give normal light they cannot be reckoned as perfect lamps.

We will now adjourn further general remarks to glance round the prominent firms and companies in the industry.

Joseph Bourne and Son have during the last season been exceptionally busy, the demand for their vitreous stone insulators and battery jars being unprecedented.

Crompton and Co.—The output of this company in all classes of work has been about double what it was the preceding year. The heaviest portion of the work has, of course, been in connection with central stations, of which we may name the Kensington and Knightsbridge, the Notting Hill and Westminster Companies in London; the Birmingham Electric Supply Company; Northampton, Southampton, Chelmsford, Swansea, and other towns. The company have increased the quantity of mains laid on the Crompton culvert system, until at the present time there is nearly 100 miles either in use or ready for use. A detailed account of this system, amply illustrated, commences in our issue of to-day. Messrs. Crompton and Co. executed a contract for an electric railway for the Southend Local Board, in a remarkably short space of time, in the course of last summer. This line has been working ever since, and has given very great satisfaction, and is, we believe, a very paying investment for the Local Board. Great strides have been made in the manufacture of dynamo machines. The average of three 200-h.p. machines recently supplied to the Birmingham Company has shown a commercial efficiency reaching 96 per cent., which the firm believe is a record of the highest results obtained by any makers. The extremely high efficiencies obtained by them and other makers are supposed to be principally due to the use of the patent twisted and compressed copper strand armature conductors. Most of the leading firms are licensed by Messrs. Crompton and Co. to use this invention, and in every case they have found enormously increased efficiency from the use of it. They have made a great many sets of electrical transmission plant for pumping and haulage in collieries. This company has been surprised to find that they are able to compete with American manufacturers of electrical machinery in their own country, and have sent out a good many sets of machinery to that country, although they have to pay a 45 per cent. import duty. As regards the foreign business, the Australian Company is very full of orders. One of the managing directors, Mr. Albright, is visiting that country, and hopes to secure the lighting of some of the largest towns, as the company has already lighted some of the smaller ones. The increasing difficulty of obtaining accurate tests of the various materials used in the business led Mr. Crompton to establish a very complete testing laboratory at Kensington. This is fitted with large accumulators, and all kinds of apparatus for the testing of copper, iron, efficiency of batteries, efficiency of dynamos, arc lamps, or arc lamp carbons. The great increase of London work has necessitated the building of a London works at Lillie-road, Kensington. These works, which were only started in the summer, have been kept fully employed up to the present, and appear likely to be so for a long time to come. In many cases there are reasons why definite information cannot be given, but we have indicated sufficiently the variety of work carried on by this firm. Thus, in electrical transmission of power, work has been done at Pleasby Colliery, at Southend, at Stanton Iron Works, and we hope to see this class of work extend in the near future very largely. Electric lighting has been carried out on a large scale from various central stations, and a considerable number of private installations.

Drake and Gorham.—The increase of business during the past year has been so marked that Messrs. Drake and Gorham have been compelled to make constant additions to their staff, and to extend their offices and stores. The number of installations carried out has exceeded the record of any previous year, clearly showing that there is still plenty of work to be done in isolated plants, in spite of the adoption of central stations. The installation at the new police buildings is now at work, and is to be completed during January, by which time the current will be available for 1,500 lamps of 16 c.p. The lighting of the exhibition at Madame Tussaud's has been working successfully for some weeks, and the firm have introduced the light to a large number of country mansions, amongst which we may mention those of Alexander Henderson, Esq., Buscot Park; Reginald Corbett, Esq., Adderley Hall; G. Singer, Esq., Conndon Court; W. Hemmant, Esq., Kippington Park; F. F. Back, Esq., Woodlands; J. C. Forster, Esq., Clatford Mills; C. Gill, Esq., Java Lodge; Lieutenant Munro, Rhinefield; H. De La Rue, Esq., The Lodge; Sir E. J. Loder, Bart., Leonardslee; Morgan and Kidd, Kewfoot-road; Cousins, Thomas, and Co., Oxford; Union Discount Co., Cornhill; Metallurgical Laboratory, King's College; Hornsby and Sons, Grantham; A. S. Bolton, Esq., Moor Court; A. Wilson, Esq., 17, Grosvenor-place; and the completion of the lighting of Alnwick Castle for His Grace the Duke of Northumberland. A large number of wiring contracts have also been completed for Sir Augustus Adderley, Lord Reay, Lady Metcalf, etc. The sale of the Cardew instruments, the patents for which are held by the firm, has considerably increased, and the use of the voltmeter has become more general. The earthing device has been accepted by the London Electric Supply Company, the Newcastle Company, and the Metropolitan Supply Company, and arrangements are made for driving the printing machinery at New Scotland Yard by means of electricity.

Electrical Accessories Company.—This company has been engaged in the arduous task of establishing a reputation, and completing its standard patterns of switches, fuses, etc., in which it is already doing a brisk trade. The orders received have considerably exceeded the manufacturing output of the works, and it is intended shortly to issue fresh capital and move into larger premises.

J. H. Holmes and Co., of Newcastle-on-Tyne, have been kept extremely busy throughout the year, their output in dynamos being about double that of any previous year. They have sold during that period 152 dynamos having an average output at usual speeds of 18,000 watts each, or equal to maintaining say 45,000 glow lamps of 16 c.p. The demand for these machines has increased so rapidly that, although the works have doubled in size during the year, the firm have been obliged to decline some urgent orders. Messrs. J. H. Holmes and Co. have, in addition to supplying other electrical engineers with dynamos, completed 66 installations of electric light in mills, factories, residences, steamships, etc.

Johnson and Phillips.—A large number of both continuous-current and alternating dynamos have been built and sold. Amongst the former were machines for the Duke of Northumberland, K.T.; the General Post Office, Birmingham; the National Museum and Libraries, Dublin (coupled direct to Willans engines); Madame Tussaud's exhibition; and many others, for important installations and for ship lighting. Amongst the latter may be mentioned complete sets for the Hong Kong central station, a machine for the extension of the Keswick central station, and several others for the Continent. Eleven sets of the Kapp central station continuous-current dynamos are now being built for the Vestry of St. Pancras, the first local authority in London that will undertake the supply of electricity themselves. The battery department has been fully occupied in making complete sets of accumulators. The vulcanised rubber shops have also been full of work, making cables for the electric light and transmission of power. The business in the Brockie-Pell arc lamp department has been extremely satisfactory, and shows a very large increase over 1889. Amongst the numerous establishments where this lamp has been introduced during the year may be mentioned the following: General Post Office, London; General Post Office, Birmingham; the Royal Mint, London; the Government Quays, Sydney, N.S.W.; the National Museum and Libraries, Dublin; "The Empire," and many other theatres; Madame Tussaud's exhibition; the Gaiety Restaurant; Spiers and Pond's new stores, Water-lane, E.C.; Winchester House, Old Broad-street, E.C.; Sir Arthur Guiness, Son, and Co., Limited, Dublin, etc. A large number of these lamps have also been supplied for the lighting of railway stations belonging to the Great Northern, Great Eastern, Lancashire and Yorkshire, and other companies, whilst a few alternating lamps have been placed in the streets of Newcastle-on-Tyne for public lighting. The arrangements are now on the point of completion for lighting all the principal streets and quays in Hong Kong with double-carbon 32-hour lamps on the continuous-current series system. Several additional buildings have been erected by this firm during the year to meet the general growth of the business.

Laurence, Scott, and Co.—During the past year the business of this company has made considerable strides, and for some months past all the different departments have been overfull of work, necessitating a great deal of overtime to complete the numerous orders in the factory without disappointment to the various customers. The company is now well supplied with orders for dynamos and motors, etc., from different parts of the United Kingdom and abroad. Among others nearing completion is a large dynamo to generate 2,500 amperes to be used in the reduction of aluminium, also a 40-unit continuous-current transformer, just completed for the Chelsea Electricity Supply Company, and a large 600-lighter dynamo for Messrs. J. and J. Colman, of Norwich. The company has, within the last few months, introduced a specially wound accumulator dynamo, that will charge cells and supply constant E.M.F. to lamp mains independently and at the same time. The company have already manufactured and supplied two or three of these machines, and they are working with complete satisfaction. A great demand for these is anticipated, as their advantages are so apparent. The company holds a patent for a system of underground mains, but as yet has not had an opportunity of laying any length. They hope, however, during the coming year to put them in use in both Norwich and Ipswich, when provisional orders are granted. During the year they have made lengthy and exhaustive experiments with their patent electricity meter, and have now brought it to such a point that very shortly it will be ready for the market. They say that its range is very wide and accurate, and also that the cost will enable it to be made at a very low price. The installation department has also been kept fully employed, and can point to several installations in all parts of the country, including business premises, mills, flour mills, breweries, country houses, and private residences and hotels, as well as work emanating from the development of the central supply stations at Norwich and Ipswich, where there is an increased use of electric motors, which shows a growing appreciation of their usefulness. Scott's patent instantaneous fuses have been introduced to a large extent in installation work, and give great satisfaction both to customers and fire insurance companies.

Paterson and Cooper.—During the whole of the year Messrs. Paterson and Cooper have been busy, and have carried out a large number of shiplighting installations. Amongst the vessels lighted have been the "Peruvian," "Brazilian," and "Parisian," belonging to the Allan Line; the "City of Vienna," "City of Venice," "City of Perth," and "City of Dundee," for the City Line; and the "Arranmore" and "Tuskar," for the Clyde Shipping Company. They have now in hand the lighting of the "St. Nicholas" and "St. Sunniva," the "America" and four new boats for the Manchester, Sheffield, and Lincolnshire Railway. By far the greater part of Messrs. Paterson and Cooper's manufactures are purchased by contractors who erect plant themselves, or by shippers who forward them to distant parts. In all manufacturing departments the business has been brisk. A larger number of dynamos has been turned out than in any previous year, and the sizes have all round averaged larger. Especially noticeable is the increased demand for direct-driven combinations, Chandler, Westinghouse, Tower, and other special types of engines being freely employed for coupling to the dynamos, in addition to those of the 'inary inverted open-fronted class. In the instrument and fittings department trade has also been good, a new alternating-current arc lamp having been designed which gives great satisfaction in working. Amongst the installations which Messrs. Paterson and Cooper have carried out themselves during the year are the lighting of Messrs. Symington's Stay Factory at Market Harborough, and the depot of the Tank Storage Company at Purfleet. They have also completely fitted an installation at Balnagowan Castle, Ross-shire, the residence of Sir Charles Ross, Bart.; Arthurs Club and The White Hart Hotel at Windsor have been fitted throughout, the current being furnished by supply companies. They have in hand the lighting of Messrs. Lipton's shops in London, Dublin, and Birmingham, and are at the moment at work on an installation of arc and incandescent lamps at works of the Lancaster Wagon Company. The prospects for the new year are very encouraging.

Swinburne and Co.—This firm only got into their new premises in May, and since then have had to fit up all the necessary machinery and apparatus for making transformers. In spite of this they have supplied several to various power stations in England, and also taken orders for abroad. The firm sees a good prospect of developing large businesses in France, Germany, Austria, and Italy, as well as in the United States, and are executing several foreign orders. Though business, as might be expected, does not seem to be so brisk just at the close of the year as it was a few months ago, still the works are considerably behind with the orders.

Ransomes, Sims, and Jefferies.—During the past year Messrs. Ransomes, Sims, and Jefferies, of Ipswich, who have always been well to the fore in the adaptation of their engines for electric light purposes, have, we are glad to find, considerably extended their connections in this department. They have supplied and erected a very fine 30-h.p. compound stationary engine, fitted with patent automatic expansion gear, at Fareham, in Hampshire, one of the small towns in which the electric light has been adopted, it being the third town in England wholly lighted by electricity. The lighting is undertaken by the Fareham Electric Light Company, who have an overhead installation throughout. The wires are carried on tall poles, to comply with the Board of Trade regulations, and as the principal street is a long straight one, this method of wiring does not present any great difficulty. The two chief streets, with a united length of about a mile, are lighted with 21 arc lights on the Thomson-Houston system. Each lamp is calculated to give a light of 1,200 candles, but owing to the use of opal globes to disperse the light, probably each lamp does not give an actual light of more than 900 candles. The result is, however, eminently satisfactory, as the streets in question are so light that good print can be easily read at any part of them. The other streets of the town are lit by incandescent lamps of 20 c.p. each, and by arrangement with the Local Board are placed at every point where a gas lamp was situated. As the gas lamps only gave a light of 15 c.p., there is a slight gain of light at each lamp. There are thus two systems, necessitating two separate sets of wire, one for each kind of lamp. For the public lighting about 12 miles of wire are used. It is insulated with okonite. Another set of wires will shortly be run for the purpose of private lighting. The central station, where the motive power and the dynamos are situated, is a long building, built of brick, and the end of it, which contains the dynamos, is matchboarded in order to keep out damp. It is furnished at present with a boiler, an engine, and two dynamos, one for the arc lights and one for the incandescent. At the recent Edinburgh Exhibition one of Messrs. Ransomes 10-h.p. long-stroke engines was employed for driving the exhibits of Messrs. Norman and Son, Limited, giving, we understand, the most unqualified satisfaction. In addition to these and other engines for England Messrs. Ransomes have sent some of their engines this year for electric light installations in India, so that there is hardly any part of the world in which Messrs. Ransomes' engines are not found driving electric light machinery of various systems.

THE SCHOOL OF ELECTRICAL ENGINEERING have during the past year considerably increased their apparatus, more particularly in the dynamo department, other dynamos having been added, making five in all, of various types, and the present gas engine, which has been too small for their requirements, will be replaced by an 8-h.p. gas engine. This is in addition to their present steam engine, making altogether a very comprehensive model installation. The teaching has been considerably modified to keep up with the requirements of the time, and a great deal more attention has been paid to mechanical engineering. The number of students during the past year has been about 40. Examinations of a practical nature have been carried out by Mr. Gisbert Kapp for the electrical engineering, and Mr. H. R. Kempe, of the General Post Office, in the telegraphic and telephonic classes. The school has recently suffered a great loss in the sad death of Dr. Lant Carpenter, one of its joint managers, but during his illness for the last eight or nine months his co-manager, Mr. Leon Drugman, M.I.E.E., has carried on the work alone, and the school will continue as before. The professors and teachers are Mr. Chas. Capito, M.I.C.E., M.I.E.E., Mr. E. C. Rimington, A.I.E.E. (who has been away on account of health, but resumes his duties in April), Mr. E. T. Carter, A.I.E.E., Mr. E. Wythe Smith, A.I.E.E. Mr. Drugman, besides acting secretary, also takes the course in telegraphy.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E

LECTURE IV.

(Continued from page 575, Vol. VI.)

You may remember that I produced an apparatus, Fig. 27, which I said was the only apparatus hitherto devised which did directly prove experimentally the law of inverse squares for the case of a magnetic pole. There was in it a pole, virtually a point at a considerable distance from a small magnetic needle, which was also virtually a point.

The law of inverse squares is true; but it is not what one works with when one deals with electromagnets having ends of a visible size, acting on armatures themselves of visible sizes, and quite close to them. If you take a case which never occurs in practice, an armature of hard steel, permanently magnetised, so far away from an electromagnet (or, rather, from one pole only) that the distance between the one pole and the armature on which you are acting is so very great compared with each of them, that each of them may be regarded by comparison as a point, then the law of inverse squares may be rightly applied, but not unless.

Now we want to arrive at a true law. We want to know exactly what the law of action of the coil and plunger is. It is not a very difficult thing to work out, provided you get hold of the right ideas. We must begin with a simple case, that of a short coil consisting of but one turn, acting on a single point-pole. From this we may proceed to consider the effect on a point-pole of a long tube of coil. Then we may go on to a more complex case of the tube coil acting on a very long iron core; and, last of all, from the very long iron core we may pass to the case of a short core.

You all know how a long tube of coil such as this will act on an iron core. Let us make an experiment with it. I turn on the current so that it circulates around the coil along the tube, and when I hold in front of the aperture of the tube this rod of soft iron it is sucked into the coil. When I pull it out a little way it runs back, as with a spring. The current happens to be a strong one—about 25 amperes; there are about 700 turns of wire on the coil. The rod is about 1in. in diameter and 20in. long. So great is the pull that I cannot pull it entirely out. The pull was very small when the rod was outside, but as soon as it gets in it is pulled actively, runs in, and settles down with the ends equally protruding. The tubular coil I have been using is about 14in. long; but now let us consider a shorter coil. Here is one here only half an inch from one end to the other, but I have one somewhere still shorter, so short that the length, parallel to the axis, is very small compared with the diameter of the aperture within. The wire on it consists of but one single turn. Taking such a coil, treating it as only one single ring, with the current going once round, in what way does it act on a magnet that is placed on the axis? First of all, take the case of a very long, permanently magnetised steel magnet, so long, indeed, that any action on the more distant pole is so feeble that it may be disregarded altogether, and only one pole, say the north pole, is near the coil. In what way will that single turn of coil act on that single pole? This is the rule, that the pull does not vary inversely as the square of the distance, nor as any power at all of the distance measured straight along the axis, but inversely as the cube of the slant distance. Let the point O in Fig. 58 represent the centre of the ring, its radius being y. The line O P is the axis of the ring, and the distance from O to P we will call x. The slant distance from P to the ring we will call a.

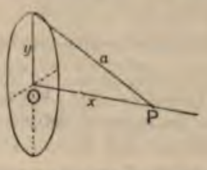

FIG. 58.—Action of Single Coil on Point-pole on Axis.

Then the pull on the axis towards the centre of this coil varies inversely as the cube of a. That law can be plotted out in a curve for the sake of observing the variations of pull at various points along the axis. Allow me to draw your attention to Fig. 59, which represents a section or edge view of the coil. At various distances right and left of the coil are plotted out vertically the corresponding force, the calculations being made for a current of 10 amperes, circulating once round a ring of one centimetre radius. The force with which such a current acts on a magnetic pole of unit strength placed at the central point is 6·28 dynes. If the pole is moved away down the axis, the pull is diminished; at a distance away equal in length to the radius it has fallen to 2·22 dynes. At a distance equal to twice the radius, or one diameter, it is only 0·56 dynes, less than one-tenth, of what it was at the centre. At two diameters it has fallen to 0·17 dyne, or less than 3 per cent.; and the force at three diameters is only about 2 per cent. of that at the centre.

If, then, we could take a very long magnet, we may utterly neglect the action on the distant pole. If I had a long steel magnet with the south pole 5ft. or 6ft. away, and the north pole at a point three diameters—*i.e.*, 6 centimetres in this case—distant from the mouth of the coil, then the pull of the current in one spiral on the north pole, three diameters away, would be practically negligible; it would be less than 2 per cent. of what the pull would be of that single coil when the pole was pushed right up into it. But now, in the case of the tubular coil, consisting of at least a whole layer of turns of wire, the action of all the turns has to be considered. If the nearest of the turns of wire is at a distance equal to three diameters, all the other turns of wire will be at greater distances, and, therefore, if we may neglect such small quantities as 2 per cent. of the whole amount, we may neglect their action also, for it will be still smaller in amount. Now, for the purpose of arriving at the action of a whole tube of coil, I will adopt a method of plotting devised by Mr. Sayers. Suppose we had a whole tube coiled with copper wire from end to end, its action would be practically the same as though the copper wire were gathered together in small numbers at distant intervals. If, for example, I count the number of turns in a centimetre length of the actual tubular coil which I used in my first experiment, I find there are four. Now, if instead of having four wires distributed over the centimetre I had one stout wire in the middle of that space to carry four times the current, the general effect would be the same. This diagram, Fig. 60, is calculated out on the supposition that the effect will not be greatly different if the wires were aggregated in that way, and it is easier to calculate. If, beginning at the end of the tube marked A, we take the wires over the first centimetre of length and aggregate them, we can draw a curve, marked 1, for the effect of that lot of wires. For the next lot we could draw a similar curve, but instead of drawing it on the horizontal line we will add the several heights of the second curve on to those of the first, and that gives the curve marked 2; for the third part, add the ordinates of another similar curve, and so gradually build up a final curve for the total action of this tubular coil on a unit pole at different points along the axis. This resultant curve begins about 2½ diameters away from the end, rises gently, and then suddenly, and then turns over and becomes nearly flat with a long level back. It does not rise any more after a point about 2½ diameters along from A; the curve at that point becomes practically flat, or does not vary more than about 1 per cent., however long the tube may be. For example, in a tubular coil 1in. in diameter and 20in. long, there will be a uniform magnetic field for about 15in. along the middle of the coil. In a tubular coil 3 centimetres in diameter and 40 centimetres long, there will be a uniform magnetic field for about 32 centimetres along the middle of the coil. The meaning of this is that the value of the magnetic forces down the axis of that coil begins outside the mouth of the tube, increases, rises to a certain maximum amount a little within the mouth of the tube, and after that is perfectly constant nearly all the way along the tube, and then falls off symmetrically as you get to the other end. The ordinates drawn to the curve represent the forces at corresponding points along the axis of the tube, and may be taken to represent not simply the magnetising force, but the pull on a magnetic pole at the end of an indefinitely long, thin steel magnet of fixed strength.

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* Cantor lectures, delivered before the Society of Arts.

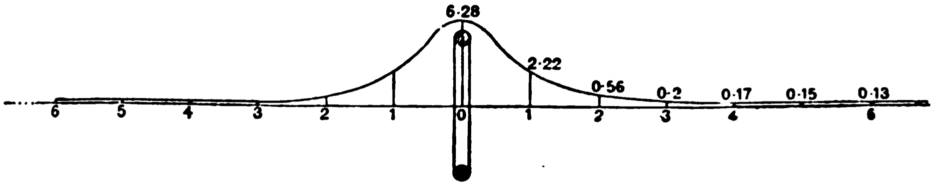


FIG. 59.—Action along Axis of Single Coil.

The rule for calculating the intensity of the magnetic force at any point on the axis of the long tubular coil within this region where the force is uniform is:

$$H = \frac{4}{10}\pi \times \text{the ampere-turns per cm. of length.}$$

And, as the total magnetising power of a tubular coil is proportional not only to the intensity of the magnetic force at any point, but also to the length, the integral magnetising effect on a piece of iron that is inserted into the coil may be taken as practically equal to $\frac{4}{10}\pi \times$ the total number of ampere-turns in that portion of the tubular coil which surrounds the iron. If the iron protrudes as much as three diameters at both ends, the total magnetising force is simply $\frac{4}{10}\pi \times$ the whole number of ampere-turns.

Now that case is of course not the one we are usually dealing with. We cannot procure steel magnets with unalterable poles of fixed strength. Even the hardest steel magnet, magnetised so as to give us a permanent pole near or at the end of it—quite close up to the end of it when you put it into a magnetising coil—becomes by that fact further magnetised. Its pole becomes strengthened as it is drawn in, so that the case of an unalterable pole is not one which can actually be realised. One does not usually work with steel; one works with soft-iron plungers which are not magnetised at all when at a distance away, but become magnetised in the act of being placed at the mouth of the coil, and which become more highly magnetised the further they go in. They tend, indeed, to settle down, with the ends protruding equally, for that is the position where they most nearly complete the magnetic circuit; where, therefore, they are most completely and highly magnetised. Accordingly, we have this fact to deal with, that whatever may be the magnetising forces all along a tube, the magnetism of the entering core will increase as it goes on. We must therefore have recourse to the following procedure. We will construct a curve in which we will plot not simply the magnetising forces of the spiral at different points, but the product of the magnetising forces into the magnetism of the core which itself increases as the core moves in. The curve with a flat top to it corresponds to an ideal case of a single pole of constant strength. We wish to pass from this to a curve which shall represent a real case, with an iron core. Let us still suppose that we are using a very long core, one so long that when the front pole has entered the coil the other end is still a long way off. With an iron core of course it depends on the size and quality of the iron as to how much magnetism you get for a given amount of magnetising power. When the core has entered up to a certain point, you have all the magnetising forces up to that point acting on it; it acquires a certain amount of magnetism, so that the pull will necessarily go on increasing, and increasing although the intensity of the magnetic force from point to point ng the axis of the coil remains the same, until within about two meters from the far end. Although the magnetic force inside long spiral remains the same, because the magnetism of the e is increasing, the pull goes on increasing and increasing (if the n does not get saturated) at an almost uniform rate all the way the piece of iron has been poked pretty nearly through to end. In Fig. 61, a tubular coil, B A, is represented.

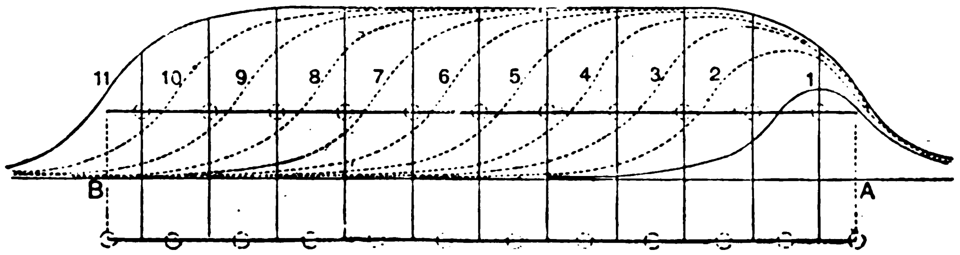


FIG. 60.—Action of Tubular Coil.

Suppose a long iron core is placed on the axis to the right, and that its end is gradually brought up toward B. When it arrives at X the pull becomes sensible, and increases at first rapidly, as the core enters the mouth of the tube, then gently, as the core travels along, attaining a maximum, C, about at the further end, A, of the tube. When it approaches to the other end, A, it comes to the region where the magnetising force falls off, but the magnetism is still going on increasing, because something is still being added to total magnetising power, and these two effects nearly balance one another, so that the pull arrives at the maximum. This is the highest point, C, on the curve; the greatest pull occurring just as the end of the iron core arrives at the bottom or far end of the tubular coil; from which point there is a very rapid falling off. The question of rapidity of descent from that point depends only on how long the core is. If the core is a very long one, so that its other pole is still very far away, you have a long, slow descent going on over some three diameters, and gradually vanishing. If, however, the other pole is coming up within measurable distance of B, then the curve will come down more rapidly to a definite point, X_1. To take a simple case where the iron core is twice as long as the coil, its curve will descend in pretty nearly a straight line down to a point such that the ends of the iron rod stand out equally from the ends of the tube.

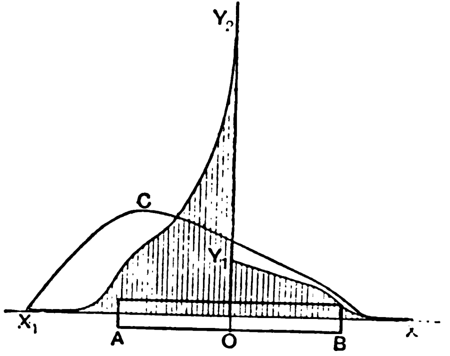


FIG. 61.—Diagram of Force and Work of Coil and Plunger.

Precisely similar effects will occur in all other cases where the plunger is considerably longer than (at least twice as long as) the coil surrounding it. If you take a different case, however, you will get another effect. Take the case of a plunger of the same length as the coil, then this is what necessarily happens. At first the effects are much the same, but as soon as the core has entered about half, or a little more than half its length, you begin to have the action of the other pole that is left protruding outside tending to pull the plunger back, and although the magnetising force goes on increasing the further the plunger enters, the repulsion exerted by the coil on the other pole of the plunger keeps increasing still faster as this end nears the mouth of the coil. In that case the maximum will occur at a point a little further than half way along the coil, and from that point the curve will descend and go to zero at A; that is to say, there will be no pull when both ends of the plunger coincide with the two ends of the coil. If you take a plunger that is a little shorter than the coil, then you find that the attraction comes down to zero at an earlier period still. The maximum pull occurs earlier, and so does the reduction of the pull to zero, there being no action at all upon the short core when it lies wholly within that region of the tube within which the intensity of the magnetic force is uniform. That is to say, for any portion of this tube corresponding to the flat top of the curve of Fig. 60 if the plunger of iron is so short as to lie wholly within that region, then there is no action upon it. It is not pulled either way.

(To be continued.)

CORRESPONDENCE.

GRAVESEND LIGHTING.

To the Editor of the Electrical Engineer.

Sir,—As desired by you in your leading article of the 26th Dec., I write to say that the statement concerning the Gravesend lighting therein referred to is, so far as this company is concerned, absolutely without foundation.

It is, I believe, well known that this company has long since discontinued installation work, and it has nothing whatever to do either directly or indirectly with the promotion or carrying out electric lighting works.

We do not know how the "error" or misstatement has arisen—we have had no communication with anyone concerning an electric light station at Gravesend.

I beg, therefore, to give the statement a "direct and unmistakable denial."—Yours, etc.,

S. Flood Page, Secretary and Manager.
Edison and Swan United Electric Light Company,
Limited, 31st December, 1890.

SECRET SOLUTIONS.

To the Editor of the Electrical Engineer.

Sir,—In reference to your short leader in your issue of the 19th Dec., will you kindly allow me to say that, as honorary secretary and member of council of this institute, my only interest in any invention brought before our members at our evening meetings is that it is one *worthy* of notice. I have had a pretty wide experience, extending over many years, of primary batteries, and I am by no means sweet on them, as the saying goes. Some four years ago I was taken to see Mr. Gauzentes' battery and it impressed me favourably. Since then he has plodded away at his electrical inventions in an earnest practical manner, and when he recently showed me the results of his labours I advised one of our evening meetings being devoted to the subject.

Before asking Mr. Spagnoletti to take the chair a miner's lamp duly charged was handed by Mr. Gauzentes to him, and left with him at his own house for trial and test. This lamp lasted out the time stated, and by further immersion of the zincs endured for 20 hours. Mr. Spagnoletti would have presided at the meeting, but at the last moment he was telegraphed to the City and South London Electric Railway, to which he is the consulting engineer, for a conference with the chairman of that company previous to the opening of the railway for public traffic on the following day.

The sole reason of Mr. Gauzentes' secresy is his immediate inability to secure the foreign patents necessary for the protection of his inventions.—Yours, etc.,

S. T. Mackie, Honorary Secretary.
Inventors' Institute, 27, Chancery-lane, W.C.,
27th December, 1890.

COMPANIES OF 1890.

The following are the principal new electrical companies that have been registered during the past year :

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Shares.	Deposit.	Total. Deposit
	£	£	£	£	£
Column Printing Telegraph	100,000	50,000	1 0 0	0 15 0	37,500
Devon and Cornwall Electricity Supply	100,000	75,000	5 0 0	1 0 0	15,000
Electrical Engineering Corporation	170,000	77,000 20,000	5 0 0 Debs.	1 10 0 30 p. c.	29,100
Electric and General Investment	200,000	190,000	5 0 0	1 0 0	20,000
Elmore's Austro-Hungarian Patent Copper Depositing	200,000	200,000	2 0 0	1 0 0	100,000
Elmore's French Patent Copper Depositing	200,000	200,000	2 0 0	0 15 0	75,000
Elmore's Wire Manufacturing	300,000	200,000	2 0 0	1 10 0	150,000
Foreign and Colonial Electrical Power Storage......	100,500	100,500	5 0 0	2 5 0	40,500
General Electric Power and Traction	350,000	350,000	10 0 0	2 10 0	87,500
Notting Hill Electric Lighting	100,000	94,500	10 0 0	1 0 0	9,450
Venezuela Telephone and Electrical Appliances	140,000	70,000 70,000	1 0 0 Debs.	0 5 0 25 p. c.	25,000

UNDERGROUND ELECTRIC WORK.

BY DAVID BROOKS.

While looking over the proceedings of the Chicago Electric Club, as printed in your paper, I was preparing myself to walk into that concern and make a disturbance, when I found Herbert Laws Webb had forestalled me, and taken a portion of the wind out of my sails. Still there is a good deal that is left undone. Mr. Degenhardt states: "The insulation resistance should not be less than 500 megohms per mile, and the insulation should not materially deteriorate for the space of two years after being in service on an electric light circuit, having a voltage of from 2,500 to 3,000 volts, and a current of from nine to 12 amperes, or a voltage of from 900 to 1,200 volts, and a current of from 18 to 20 amperes." A galvanometrical test of this nature for an electric light conductor I consider of no earthly use, but agree with Wm. Maver, jun., in an article published in the *Western Electrician* of March 1st, 8th, and 15th of the present year, that a cable measuring 20,000 megohms per mile for insulation in the factory, was broken down by a dynamo current of 600 volts after being drawn into a conduit. In speaking of all these tests, Mr. Degenhardt makes no reference to temperature, although in a Chicago atmosphere the insulation resistance is certainly 10 times as high at the temperature of freezing as at the temperature of 80.

As Mr. Webb states, the cable should be immersed in water, but even that is not satisfactory if the cables are to be used for electric lighting purposes. The method employed by Johnson and Phillips, of London, is spoken of as follows, in a letter under date of November 4th last, referring to a line laid at Charlton: "We have at last had Ferranti, Dr. Fleming, Gordon, and others down to see it. Yesterday we had a current of about 14,000 volts on this line for about five hours, and it stood it perfectly; we took the current from a 2,000-volt Kapp alternator and transformed up to 14,000 volts to the line. At the distant end we had another transformer and converted it to 2,000 volts again, and lighted 20 100-volt 16-c.p. lamps in series, and I am writing to Ferranti and others to come and see the test repeated."

Cables that may test enormously high with a galvanometer often break down and disrupt with currents of high voltage, and especially is this the case with lead-encased cables; the coiling and uncoiling of this class opens spaces in the insulation which are nothing more than vacuum tubes or Geisler tubes. Varley made use of these years ago to protect ocean cables from atmospheric electricity. Last winter I laid an electric light cable in Gloucester, a No. 0 conductor; the insulation resistance of that cable at 32deg. F. is 1,000 megohms per mile; but in August last, when the temperature of water from the hydrant was at 81, the insulation dropped to three megohms per mile. This cable stood the current of a 2,000-volt alternating current, but, as an experiment, we heated a portion of the cable up to 150deg. F., and brought the insulation down to 5,000 ohms per mile, and tried to break or disrupt the insulation without any effect whatever. It was then tested with a Holtz machine, which produced a spark 6in. in length, to ascertain whether the insulation could be punctured, but without effect. Five thousand ohms per mile does not sound very high, but if the conductor was a No. 3 instead of a No. 0, only one part of the current would go to the earth, while 5,000 parts would keep to the wire.

Currents of great intensity centre upon weak spots and develop them into perfect grounds. Culley speaks of this fact, and it is for that reason chiefly that the Atlantic cables are worked with only two cells, and nothing can be more absurd than the statement, "Electrical currents of infinitesimal potential are no more easily conducted than are those electrical giants of four or five thousand volts." It has especial bearing upon lead-covered cables with inside textile covering. Coiling and uncoiling is liable to open pores, admitting moisture, especially so when laid under water.

Mr. Sunny says: "In arc light service if we get one megohm to the mile we are perfectly contented." Mr. Sunny, speaking of telephone cables, says: "The company also put down what was known as the Brooks cable in a 3in. iron pipe filled with resinous oil. It extended from the business part of the city to Twenty-second-street, and never gave satisfaction from the outset. I believe it is still working in some sections, but not in a satisfactory manner." In this connection I quote from Prof. Barrett: "Now, then, the question of insulation is another thing. You can get all the insulation you want and a good deal more. I recollect a short time ago that a cable was abandoned here because the insulation was so high that they could not use it. Gentlemen in the room know that to be a fact. They had to reduce the insulation so that the cable would work." A few days ago I was in Chicago, and Prof. Barrett said the words just quoted had reference to the Brooks cable in that city laid four years since. When the cable was first laid, Mr. Sunny wrote that it was a perfect success; in the next letter he stated there was a great deal of retardation on the Brooks cable when an overhead cable was connected into it at Twenty-second-street, and when it was still lengthened by connecting in another cable at La Salle-street, the Brooks cable as a trunk line was nearly worthless; but taking the "poorest insulated wire," they could use it fairly well.

I got Geo. H. Bliss to try the cable himself, and he wrote as follows: "Scarcely any cross-talk or induction sounds could be heard by me on Brooks cable wires in any of these tests. Pronunciation of difficult names was tried on all the Brooks wires with success, except in those cases especially difficult for telephone transmission. This afternoon I went, at Mr. Brooks's request, to the Chicago Avenue exchange, where conversation was carried on through a wire in a Patterson cable to the La Salle-street exchange, about one mile distant. The cross-talk and induction were much more pronounced than on the Brooks cable wires used in the morning, although the distance was only one-third as great."

History has record of the better working of ocean cables by putting in leaks. Culley speaks of it in the cables that are laid from island to island in the Mediterranean. Sabins, in his work published in 1867, states that Kramer improved the insulation of the underground wires in Germany by reducing the insulation, so there is nothing wonderful in the statement of Mr. Sunny that the poorest insulated worked the best. The great fault with the cable is that the conductors were too large, No. 16; if they had been No. 22 the inductive disturbance would not have been more than half as great. I protested against the use of such heavy conductors, there being 510 in a 3in. pipe. What is needed in telephone service is not so much volume as distinctness of articulation. Since then I laid a cable of 53 conductors for the Pennsylvania Railroad Company, of Philadelphia, and one of them was a very small wire, No. 22, laid for the purpose of a test wire. This cable is used for both telephonic and telegraphic purposes, and it has been found that the small wire serves much better than any of the others for telephone uses, for the reason that it occupies no more than half the space in the inductive field. Using the No. 16 wire you do not reduce the resistance of the circuit, which includes telephones and transmitters, 1 per cent., but you increase the inductive disturbance 50 per cent.

As an experiment we connected in as many as 10 of the No. 16 wires, using them in parallel, and thereby reducing the resistance to merely nothing, or next to nothing, and then listened to the noise. We were enabled to hear the hum of the electric light dynamos. The amount of this is to show that there has been a great deal of copper wasted in telephone cables of short length, but in long distance telephoning, where the circuit is double in length to make it metallic, then conductivity becomes essential.

Mr. Sunny, referring to electric light cables, makes the following statement: "In the electric lighting business I claim that the underground work is not a complete success for the reason that the lights are apt to go out once a week from some underground defect. The insulation is liable to run down so low on short notice as to require the shutting down the circuit for repairs." Now, with the Brooks's system, patented in 1887, an entirely different state of affairs exists. With nine installations working, most of them upward of a year, not a single interruption has occurred. Prof. Barrett states: "It is a fact with the underground system of Chicago to-day that you deliver more of your product at the lamp than you did with the overhead system." At Gloucester we used Johnson and Phillips's method of insulating the lamps, and with 22 terminals exposed to the rain, we got a much higher insulation than on a clear day at the same temperature, because some of the pipes and lampposts are exposed to the rays of the sun. An ordinary glass insulator exposed to the smoke and soot will not show in Chicago, in the rain, an insulation of over a megohm, and there is a great deal in this particular point of carrying the full current to the lamps as pointed out by Prof. Barrett. There is much said about subways and conduits. I consider the best of them an unmitigated nuisance, and of no earthly use. Nineteen No. 4 electric light conductors can be drawn into a 2in. diameter pipe, the conductors not costing over five cents a foot. Think of what Mr. Laws says, a good electric light conductor can be had for 1,250dol. per mile, and that Mr. Degenhardt says the rental of a duct is 1,000dol. a mile per annum. If electric light companies must pay these figures they should never be obliged to go underground. Mr. Kemp says: "I think in this discussion a comparison of the cost ought to be mentioned for good reasons. So if any gentleman is prepared to give us some figures, showing the difference in cost between aerial and underground construction, I should like to hear them." I should very much like to go into figures, but it is impossible to do so unless one knows what is wanted. If a person should ask me how much it costs to build houses, I should state that it depends very much on the kind of a house you want, and if anyone will specify what is required I will at once estimate for the work, and promise that it does not cost one sixth of any other underground system, and but little or if any more than an overhead system.

Two years since a wood conduit was laid on Chestnut-street, Philadelphia, and the street being narrow, the traffic was incommoded by immense heaps of earth that were thrown out. Some electric light wires have been drawn into them, and the conduit has taken fire twice between Seventh and Eighth streets, destroying all the conductors, and a portion of the conduit had to be rebuilt. There have been several other fires that have come under my notice, one at Fourth and Chestnut, and another at Eleventh and Chestnut. There the conduit had to be rebuilt for half a square. Not more than a couple of weeks since an explosion occurred at Ninth and Chestnut streets, breaking every window upon one side of a street car.

There are four conduits in Chestnut-street. In this same locality, but on the south side of the street, a manhole blew up, and sent up the cover through the window, which consisted of a large French plate glass, into the store of Porter and Coates. Between pumping water out and fanning fresh air into these conduits, there is quite a new industry established.

The idea that you can pull in and pull out in making repairs is popular, and that you have spare ducts to put in more conductors when needed, is also popular; but in practice here the first thing necessary after you pull in a cable, is to pull it out again and repair damages. Rubber and guttapercha are soon destroyed when exposed to the atmosphere of a wood conduit. Lead is turned into white lead. Prof. Marks calls wood conduits white lead factories. To preserve the white lead they cover it with a braid saturated with black paint. When drawn into the conduit the paint is as dry as any other paint after it is exposed to the air, and does not adhere to the hand, but after it has been in the conduit a week, this paint becomes liquid, thinned, and leaves a black mark on your hand if you touch it. Illuminating gas is only another form of hydrocarbon or fatty matter, and acts as a solvent, like benzine upon grease spots. The paint and braid preserve the lead for a while, but are not lasting. About a month since they undertook to draw in some electric light conductors in this wood conduit at Broad and Chestnut-streets, and after punching with their iron rods to get a passage for pulling in rope, they found the conduit was rotten, and the whole thing for 60ft. or more across Broad-street, the widest street in Philadelphia, had to be dug up and a new conduit laid. Broad-street at this place is paved with asphalte, and the gang of men were making repairs there for about 10 days. Broad-street is Fourteenth-street if numbered. When they got as far as Fifteenth-street they had another circus of the same nature and had to put in a new duct. It seems to me that anybody that would spend money for a conduit at this time must be demented, yet another company is now laying in this same Broad-street a wood conduit. I consider this a case of aggravated dementation: "If the blind lead the blind, both fall into the ditch," which is the scripture name for conduit. I must quote a scrap from an author of the twelfth century, Mr. Dante: "These may be called flocks of sheep, and not men; for if one sheep should throw himself down a precipice of a 1,000ft. all the rest would follow; and if one for any cause in passing a road should leap, all the rest would do the same, though they saw nothing to leap over."

EDISON AND THE INTERVIEWER.

[We reproduce below an interesting account of an interview with Edison.—Ed. *E.E.*]

Thomas Alva Edison should be a very happy man. Since the days when he was a telegrapher in Boston fortune has smiled upon him every hour in the twenty-four. It is not too much to say, perhaps, that he is the best known American.

His wonderful ingenuity or genius has made his name a household word the world over, and yet he is only forty-three years of age. During his lifetime he has taken out over 400 patents on his own inventions. From the hour when the incandescent light became a practical illumination his fortune has gone on piling up in such proportions that he may safely be estimated to be worth from three to five millions of dollars. He is one of the few men of inventive genius who has made anything out of his patents.

He is happily married to a daughter of the many times millionaire, Miller, of Akron, Ohio. A charming woman, who will some day add from three to five millions more to her husband's fortune.

Charming Environments.

The visitor to Edison's home and laboratory at Llewellyn Park, on the Orange Mountains, a few miles from Jersey City, is surprised and gratified by the beauty of the scene. The Wizard of the New World occupies a beautiful villa that was built by a man who decamped with a large fortune, and threw the property on the market at a sacrifice. Edison's luck was present at this hour, and he bought the handsome place for a song. Llewellyn Park is one of the most charming spots imaginable. There is no place in it for a poor man. Only the wealthy can inhabit the fine houses that dot the mountain side. There are walks and drives, long paths of green shade trees, and the delicious aroma that comes from innumerable flower beds. A splendid view is obtained from many of these mansions, a view of seven large cities with a population of more than four million souls. A short 10 minutes' walk from Edison's house brings you to his laboratory, perhaps the most complete in the world. You are sure to find the great inventor there at any time you call. He is an early riser, and immediately after breakfast leaves his home for his workshop. Not a workshop in the sense that the word is usually understood, but a great, big, roomy place, finished in hard wood, with fine Smyrna rugs and bear skins on the polished floor, pictures on the walls, and a library of books in a convenient corner There is a reception-room for guests, and adjoining this Edison's sanctum, where he sits hour after hour trying to solve some of the great problems that perplex him.

The Great Inventor.

You would not imagine for a moment that this man is the great inventor. His face is cleanly shaved. His shoulders are broad, and there seems to be a trifle of stoop in them. His large grey eyes are sunken in his head, and his massive Websterian forehead is furrowed with wrinkles. He is quite deaf, and this makes it quite difficult for anyone, particularly an interviewer, to ask him questions, and he is so busy that he has neither time nor patience to talk often for publication. But if you should happen to find him in a pleasant mood, as I did the other morning, you would find him one of the most companionable of men. I asked him a good many leading questions, all of which he answered in a free manner, and without the slightest hesitation. While we were talking he continued at his work. Many of his employés came to consult with him, and at his elbow was one of his numerous secretaries. He always watched the lips of the person talking to him, which assists him greatly in making out what is said. Deaf as he is, it is a little strange that he can hear through the telephone very easily.

The Vital Problem.

"Have you made any important discovery lately ?" I asked him.

"That depends," was his reply, "on what you would call important, I might call important, and the world would call important. I may say that I am at work all the time. I am now engaged on the vital question of electricity—viz., the way to obtain it direct without the aid of other motor power. It has been a study of mine for years, and I confess that I have not succeeded in making the invention. I shall never cease trying to unravel the problem. The man who makes this invention will solve the question of motor power. I would gladly acknowledge the greatness of anyone who could do this, and hail him as the king of inventors. No selfish motives of not being first would keep me from acknowledging his greatness. No other invention would so benefit and revolutionise the world. At present we have to use coal to generate steam, and it in turn gives motor power to the dynamo which produces electricity. Only about 15 or 19 per cent. of the energy of coal is thus used. The result is an expensive and vast waste. Tons of coal are used upon vessels on one trip to Europe, but if electricity can be generated directly from the coal, then only a few basketfuls will be necessary to carry the biggest vessel across the ocean. One pound of coal can carry itself around the globe with its own electrical power. Some kind of a boiler, only made smaller than the present steam boiler, may be the only means necessary to transform coal into electricity, But, of course, the apparatus, its shape, or what it will be, has yet to be invented, as well as the great problem.

Electricity from Coal.

"Have I succeeded in making any headway? Just a little. I can get some electricity direct from coal, but it has no force to speak of. It is not the true force I am looking for. I do not dream over it, but I confess I spend many hours working over it.

"Think of it. Electricity direct from coal? It may sound like an echo of the millennium, but I do not think so. We have succeeded in using electrical force in many and various ways. But electricity can never be the motor of the world if another power is necessary to generate it. The expense is too great, and so the original power is preferable, of course. Now, for a moment imagine the condition of things following this invention : Steam will become a thing of the past, and the greatest and cheapest motor power, electricity, will be universally used. Some idea may be gained of the superior power of the new motors, by stating that it will then only require three days to go to Europe, and only two or three will be consumed in a railroad trip to California. The factory that I run, which now consumes a great quantity of coal daily, will need only a small basketful of coal to keep it going all day. Great factories that annually burn thousands of tons of coal will be run on several tons, say two or three, or a few more per annum, saving many thousands of dollars. The cost of living, the cost of goods, the cost of nearly everything will be reduced. It will cost nothing to make ice. It will be a revolution, not to throw anyone out of employment, not to ruin any industry, but to benefit mankind and civilisation in general."

"Do you ever despair of making the invention or solving the problem ?

Some Use for Men of Science.

"It was reported once that you had invented a process to convert dirt into food ?"

"That was an April fool joke. But great strides are being made in that direction. People have wrong ideas about many of the edibles made artificially, and yet they are just as healthy as the natural product. You, perhaps, have heard that butter is often made out of mud from the bottom of the Thames river. It is not actually from the mud, but from the grease from sewers that gathers in the mud. Why, oleomargarine is good, if not better, and to my idea decidedly more wholesome and purer than butter, if made in an honest way. It is often made by dishonest people, and therefore is impure. No doubt some manufacturers make it better and purer than others, but when bad people, in order to get bigger profits, manufacture cheap oleomargarine it forces others to adopt the same dishonest method. But what is the use of talking about all people being honest. I do not expect the end of the world to come soon, and that would be the case if all people were honest.

Only Cheap Wires Dangerous.

"There is no reason why death should occur from coming in contact with electric wires. Dishonesty, greed, and recklessness are really the causes for all the deaths that occur from electric wires, and there is a remedy. An electric company will deliberately use small, cheap copper wires that carry a strong, deadly current, when for a larger outlay of money large copper wires, which do not carry deadly currents, could be purchased. It is simply a matter of parsimony. For instance, a company will frequently use small copper wires that cost 2,000dols., knowing full well that a deadly current will be in them, rather than pay 8,000dols. or 10,000dols. for large wires that would be harmless. Yet there is a cry against the deadly electric wires. Some of my wires in Lower Broadway are in constant use, and no one has ever been hurt by them. Why? The wires are large, and will last safely until the twenty-fifth century. As long as there are no laws regulating the sizes of electric wires, of course, fatalities may be expected. Steam boilers are inspected, and why electric wires are not is a mystery to me. They could be policed, so to speak, and made as safe as waggons running along the streets."

Gas as Fuel.

"Do you think that lighting by electricity is becoming more popular?"

"Certainly ; because it is getting cheaper every day, and gives a better light than gas. I do not mean to say that gas will be driven out of use, for it will not. It will certainly be done away with as lighting material, and will be used chiefly to heat, nothing more. Already many gas companies have turned their attention towards heating, and succeeded admirably. As a lighting material gas smokes, but used in heating it does not. The smoke from a gas stove usually goes up the chimney, and gas, as a fuel, is much cheaper and cleaner than coal. There are no ashes, no trouble, and none of the annoyances that come with handling coal. This is beginning to be the era of gas heating. Look at the gas used in many towns, where natural gas has been discovered. Why cannot gas be made for heating purposes just as reasonable in price as for lighting? The cost is much smaller than coal or wood heat, and infinitely preferable. Electricity is essentially adapted for lighting purposes, and is superior in many respects. It is becoming cheaper every day. Only 2 per cent. of the coal is turned into light, while nearly all the electric force is turned into light. It is really a saving to use gas for heat, and within the past two years it has become very popular as a heating medium."

About Flying Machines.

"Have you ever thought of inventing a flying machine, the motor force of which would be electricity?"

"Yes, I have given some study to the question, and, of course, made some experiments in that direction. The bumblebee is a fine model to study for a flying machine, and the more I study that species of a high order of birds, the more complex does the flying machine problem appear. The bumblebee flies by the aid of motor power alone. It has no natural aid, but must depend upon the rapid working of its wings to fly. There is no wind and no feathers to assist the bee ; it has small wings, entirely out of proportion to its large, robust body, and when it flies the wings, as any observer can see, are worked so rapidly it is impossible to calculate the number of flops to the minute. But the little bird must, perforce, be the model to solve the flying machine puzzle, because it is propelled simply by native motive power. Could this bumblebee carry the weight of another bee on its back is a question often asked. Well, it cannot; and even if a flying machine were invented on its model it would not be capable of carrying any weight save its own. Nature has done so much, and failed to go any further.

"You see, if wings were applied to a man they would have to be quite small in order to be worked rapidly. Large wings could not be moved rapidly enough, so the question of flying would never be settled by large wings, even if the motive propelling power were a thousand times greater than any yet conceived of. A man might have wings constructed to carry his weight, but that would be all. Like the bumblebee, he would be unable to do anything save carry his own weight, and that by sheer force of great power. Now, seagulls have large wings, entirely out of proportion with their small bodies. But they have little motive power, and are simply kept up like a kite by the wind. If you will notice a gull you will rarely see it work its wings, but it keeps them outstretched and sails around the air in a beautiful style. No flying machine could skim about on the bosom of the wind like the seagull. All birds propel themselves by flying and sailing. It is a natural action, but man cannot acquire it, at least not now in this day and generation, when so many secrets of nature slumber before the *savant's* eyes for years. We can only go back to nature and pause and wait for years to understand the phenomena that now seems a mystery to our very finite minds.

"I am not so sanguine about a flying machine because nature has her limitations. Anyway, many of her secrets lie hidden from us and remain to enrich and glorify some bright and wonderful era in the future. Perhaps a century or so from now the flying principle in man will be invented or discovered. Things unheard and undreamed of may come to light in the future and place us in the category of being too stupid to imagine and much less to invent them. But I have nothing to do with the future. If there ever will be a flying machine capable of carrying not only man but other weight with it, I at present cannot conceive it. There are certain fixed principles in nature we cannot ignore. We cannot pull ourselves yet through space by our own boot straps, and we cannot leap from the top of a house without climbing on the top first."

"Why not take the bumblebee model and try it?"

"Nature made the bumblebee with motive power enough to carry its own weight and no more. Why it did not give the bumblebee more power I cannot explain ; it is beyond the comprehension of my very finite mind. Man was not constructed with wings, and so he has to wait and solve the problem which nature gave to the bumblebee and birds."

Future of the Phonograph.

"Do you think the phonograph will ever be universally used?"

"I know a number of men who at first did not like it, but now they constantly use it and save three or four hours of valuable time each day. The business man can get down to his office and talk off enough in half or one hour to his phonograph to keep five or six typewriters busy three or four hours. If that is not a wonderful time saver I would like to see it beaten. It is all well and good for a man to say that he can dictate rapidly to a stenographer ; but no matter how fast he talks to a phonograph it is all there, and anyone can hear and write it out afterwards. I predict that phonographs will entirely change the present system of answering business letters and writing communications. It is one of those inevitable things that prejudice and a lingering desire not to adapt a new method cannot affect. Look how the telephone is used now, and how it facilitates business. Well, the phonograph will soon be in vogue, and people will wonder why they had never used them before. It is one of the greatest labour-saving machines."

New Order in Telegraphy.

"Do you believe that the present style of telegraphy will soon be done away with?"

"Yes, but not until the old timers have disappeared. The operators now have a deep-seated prejudice against any inventions that will simplify telegraphy. But some of the inventions have already been made, and it is only a question of time when a man can rush into a telegraph office, scratch off a note to his wife in Chicago, and the exact duplicate of his note will be delivered over the wire to his wife. This will not be all by any means, but maps, pictures (newspaper pictures) will be transmitted promptly by wire. These new inventions will be for the coming generation to see in practical use. The old stagers will fight, of course, to keep the new order of things from coming rapidly into practical use, because it will interfere with their occupation."

After Dinner, Rest.

At six o'clock Mr. Edison stops work and goes home to dinner. The evening is spent in a drive or in chatting with some of the callers who constantly overrun the place. There is no restriction put upon visitors. A great many hundred curiosity seekers visit Llewellyn Park just to catch a glimpse of the inventor. Sometimes they succeed and many times they do not, for Edison is only human after all, and his nature is a bit perverse. By midnight the house is in darkness, except on some special occasion, when the light burns long in the library, and then it may be known that the great inventor has something on his mind, and is trying to solve an intricate problem. But as a rule his life is methodical. He goes to bed in good season, and gets up betimes.

He works hard all day and sleeps like a ploughboy at night. He seldom goes away from his home, and those who want to see him on important matters must journey out to him. He dislikes publicity very much. He has never been seen at a great public banquet in New York or elsewhere, and he finds little to interest him in the theatre or opera, although he is a great lover of music. In addition to all his other accomplishments he plays very prettily on the piano, and often passes an hour in that amusement. Perhaps while his fingers are wandering over the ivory keys his mind is in another land, where shadows become realities, and where by the touch of his magic wand he may bring forth some great invention that will benefit the entire human race.

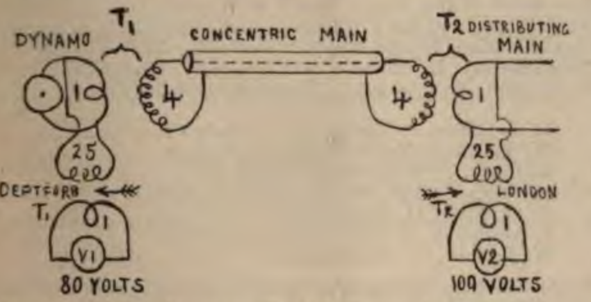
He would be wise indeed who could say what Edison will do next.

PHYSICAL SOCIETY.—Dec. 12, 1890.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

Mr. Shelford Bidwell, F.R.S., showed "**Some Experiments with Selenium Cells.**" The crystalline variety of selenium was, he said, most interesting to physicists, owing to its electrical resistance being greatly diminished by light. This property was shown experimentally with different forms of cells, the construction of which were explained. The form recommended was that in which two copper wires are wound near each other round a strip of mica, and the spaces between the wires filled with selenium. The wires form the terminals of the so-called "cell," which before being used is annealed for several hours at a temperature above 200deg.C. Many such cells were made in 1880, 1881, and their sensitiveness to light remained unimpaired during 1882. In 1885, however, several were found less sensitive, and others totally useless; only one out of thirteen retained its sensibility till September, 1890. The loss of sensitiveness, Mr. Bidwell believes due to an excessive amount of selenide of copper being formed, for although some selenide is essential to the satisfactory working of the cell, too much is fatal to its action. The selenide of one defective cell was electrolysed, red tufts of amorphous selenium appearing on the anodes. A white substance resembling moist calcium chloride was also present; this he believed to be oxide or hydroxide of selenium. Small polarisation currents had been obtained from selenium cells. A lecture apparatus illustrating the properties of selenium cell was exhibited. It consisted of a cell connected in series with a relay and a battery. The relay was arranged so that it might either ring a bell or light an incandescent lamp. When the bell was joined up it remained silent so long as the selenium cell was illuminated, but on screening the cell the bell rang. By using various coloured glasses as screens, the effect was shown to be due to the red and yellow rays. A similar experiment with the glow lamp was very striking, for on turning down the gas lamp illuminating the cell the electric lamp lighted, and was extinguished on turning up the gas. This demonstrated the possibility of an automatic lamplighter which would light or put out lamps according as they are required or superfluous. Amongst the other practical applications suggested were announcing the accidental extinction of railway signal lamps or ships' lights, and the protection of safes and strong-rooms. **Prof. Minchin** said he had lately constructed cells of a different kind to those shown by Mr. Bidwell, and found that they gave an E.M.F. when exposed to light. For his purposes the long annealings, etc., were quite unnecessary, and a complete cell could be made in 10 minutes. One of his cells gave an E.M.F. of over one volt as measured by an electrometer, by the light of a fog. Their promptness of action falls off in a day or two, but if they are kept on open circuit a week has no effect on the final E.M.F. On closed circuit, however, they deteriorate. **Prof. S. U. ickering** said both oxides of selenium were deliquescent, and the ithor's conclusion as to the white substance formed by electrolysis was probably correct. **Prof. S. P. Thompson** believed Prof. Graham Bell had tried platinum instead of copper, and found that the selenium cracked off in annealing. He also found that it was only necessary to carry on the annealing until the characteristic slate colour appeared. Mr. Bidwell's experiments, he said, showed the possibility of seeing at a distance, and had also suggested to him that the effect of screening might be utilised for driving a completely detached pendulum electrically. **Prof. Forbes** said that silver sulphide when electrolysed presented appearances resembling those noticed by Mr. Bidwell in copper selenide. In reply to questions from the president and Prof. Perry, as to whether the low resistance and unsensitiveness of old cells was due to moisture, **Mr. Bidwell** said drying them had no effect, but baking restored the resistance, but not their sensitiveness. Speaking of the effect of annealing cells, he said this reduced their resistance considerably. Prof. Graham Bell, he believed, gave up using platinum because the resistances of such cells were very high.

Mr. James Swinburne read a paper on "**Alternate-Current Condensers.**" It is, he said, generally assumed that there is no difficulty in making commercial condensers for high-pressure alternating currents. The first difficulty is insulation, for the dielectric must be very thin, else the volume of the condenser is too great. Some dielectrics 0·2 mm. thick can be made to stand up to 8,000 volts when in small pieces, but in complete condensers a much greater margin must be allowed. Another difficulty arises from absorption; and whenever this occurs the apparent capacity is greater than the calculated. Supposing the fibres of paper in a paper condenser to be conductors embedded in insulating hydrocarbon, then every time the condenser is charged the fibres have their ends at different potentials, so a current passes to equalise them and energy is lost. This current increases the capacity. One condenser made of paper boiled in ozokerite took an abnormally large current, and heated rapidly. At a high temperature it gave off water, and the power wasted and current taken gradually decreased. When a thin plate of mica is put between the foils, it heats excessively, and the fall of potential over the air films separating the mica and foil is great enough to cause disruptive discharge to the surface of the mica. There appears to be a luminous layer of minute sparks under the foils, and there is a strong smell of ozone. In a dielectric which heats, there may be three kinds of conduction—viz., metallic, when an ordinary conductor is embedded in an insulator; disruptive, as probably occurs in the case of mica; and electrolytic, which might occur in glass. In a transparent dielectric, the conduction must be either electrolytic or disruptive, otherwise light vibrations would be damped. The dielectric loss in a cable may be serious. Calculating from the waste in a condenser made of paper soaked in hot ozokerite, the loss in one of the Deptford mains came out 7,000 watts. Another effect observed at Deptford is a rise of pressure in the mains. There is as yet no authoritative statement as to exactly what happens, and it is generally assumed that the effect depends on the relation of capacity to self-indication, and is a sort of resonator action. This would need a large self-induction, and a small change of speed would stop the effect. The following explanation is suggested. When a condenser is put on a dynamo the condenser current leads relatively to the E.M.F., and therefore strengthens the field magnets and increases the pressure. In order to test this the following experiment was made for the author by Mr. W. F. Bourne. A Gramme alternator was coupled to the low-pressure coil of a transformer, and a hot-wire voltmeter put across the primary circuit. On putting a condenser on the high-pressure circuit the voltmeter wire fused. The possibility of making an alternator excite itself like a series machine by putting a condenser on it, is pointed out. **Prof. Perry** said it would seem possible to obtain energy from an alternator without exciting the magnets independently, the field being altogether due to the armature currents. **Mr. Swinburne** remarked that this could be done by making the rotating magnets a star-shaped mass of iron. **Sir W. Thomson** thought Mr. Swinburne's estimate of the loss in the Deptford mains was rather high. He himself had calculated the power spent in charging them, and found it to be about 16 h.p., and although a considerable fraction might be lost, it would not amount to $\frac{9}{10}$ths. He was surprised to hear that glass condensers heated, and enquired whether this heating was due to flashes passing between the foil and the glass. **Mr. K. P. Trotter** said Mr. Ferranti informed him that the capacity of his mains was about one-third microfarad per mile, thus making $2\frac{1}{3}$rd microfarads for the seven miles. The heaping up of the potential only took place when transformers were used, and not when the dynamos were connected direct. In the former case the increase of volts was proportional to the length of main used, and 8,500 at Deptford gave 10,000 at London. **Mr. Blakesley** described a simple method of determining the loss of power in a condenser by the use of three electrodynamometers, one of which has its coils separate. Of these coils one is put in the condenser circuit, and the other in series with a non-inductive resistance, r, shunting the condenser. If a_2 be the reading of a dynamometer in the shunt circuit, and a_3 that of the dynamometer, the power lost is given by $r\,(C\,a_3 - B\,a_2)$ where B and C are the constants of the instruments on which a_2 and a_3 are the respective readings. **Prof. S. P. Thompson** asked if Mr. Swinburne had found any dielectric which had no absorption. So far as he was aware, pure quartz crystal was the only substance. **Prof. Forbes** said Dr. Hopkinson had found a glass which showed none. **Sir W. Thomson**, referring to the same subject, said that many years ago he made some tests on glass bottles, which showed no appreciable absorption. Sulphuric acid was used for the coatings, and he found them to be completely discharged by an instantaneous contact of two balls. The duration of contact would, according to some remarkable mathematical work done by Hertz in 1882, be about 0·0004 second, and even this short time sufficed to discharge them completely. On the other hand, Leyden jars with tinfoil coatings showed considerable absorption, and this he thought due to want of close contact between the foil and the glass. To test this he suggested that mercury coatings be tried. **Mr. Kapp** considered the loss of power in condensers due to two causes—first, that due to the charge soaking in; and second, to imperfect elasticity of the dielectric. Speaking of the extraordinary rise of pressure on the Deptford mains, he said he had observed similar effects with other cables. In his experiments, the sparking distance of a 1,400-volt transformer was increased from $\frac{13}{16}$in. to 1in. by connecting the cables to its terminals. No difference was detected between the sparking distances at the two ends of the cable, nor was any rise of pressure observed when the cables were joined direct on the dynamo. In his opinion, the rise was due to some kind of resonance, and would be a maximum for some particular frequency. **Mr. Mordey** mentioned a peculiar phenomenon observed in the manufacture of his alternators. Each coil was tested to double the pressure of the complete dynamo, but when they were all fitted together their insulation broke down at the same volts. The difficulty had been overcome by making the separate coils to stand much higher pressures. **Prof. Rucker** called attention to the fact that dielectrics alter in volume under electric stress, and said that if the material was imperfectly elastic some loss would result. The **President** said that as some doubt existed as to what Mr. Ferranti had actually observed, he would illustrate the arrangements by a diagram.



Explanation of diagram: T_1 and T_2 are large transformers; t_1 and t_2 are small transformers for voltmeters V_1 and V_2. The numbers 1, 4, 1, 25, represent their conversion ratios.

Speaking of condensers, he said he had recently tried lead plates in water to get large capacities, but so far had not been successful. **Mr. Swinburne**, in replying, said he had not made a perfect condenser yet, for although he had some which did not heat much, they made a great noise. He did not see how the rise of pressure observed by Mr. Ferranti and Mr. Kapp could be due to resonance. Mr. Kapp's experiment was not conclusive, for the length of spark is not an accurate measure of E.M.F. As regards Mr. Mordey's observation, he thought the action explicable on the theory of the leading condenser current acting on the field magnets. The same explanation is also applicable to the Deptford case, for when the dynamo is direct on, the condenser current is about 10 amperes, and this exerts only a small influence on the strongly magnetised magnets. When transformers are used the field magnets are weak, whilst the condenser current rises to 40 amperes. Mr. Blakesley's method of determining losses was, he said, inapplicable, except where the currents were sure functions of the time; and, consequently, could not be used to determine loss due to hysteresis in iron, or in a transparent dielectric.

Mr. Swinburne's "**Note on Electrolysis**" was postponed till next meeting.

THE JUNIOR ENGINEERING SOCIETY.

PROF. S. P. THOMPSON ON ELECTROMAGNETIC MECHANISMS.

(*Concluded from page 477, Vol. VI.*)

In moving under the stress of the magnetic field, the armature of an electromagnet performed mechanical work. The work done would, of course, be the product of the displacement into the average force. One was led thus to institute a comparison between the work done in the stroke of an ordinary steam engine piston and the work done by the armature of an ordinary electromagnet. In neither case was the force uniform from end to end of the stroke. With the piston the pressure rose very rapidly at the beginning of the stroke, continued at its maximum for a little while, and then fell continuously to the end of the stroke. In like manner, the magnetic stress which urged the armature varied from end to end of the stroke, but in a wholly different manner. At the beginning of the stroke, when the armature was at some distance away from the fixed core, the stress was small. (This was explained by means of a magnet and armature.) If the armature approached closer, there was a still larger magnetic flux, and when it was placed in close contact they had still greater flux of magnetic lines, and therefore the stress per square inch was greater. At the beginning of the stroke, when the armature was at some distance away from the fixed core, the stress was small, as it approached the magnetic field became more intense, and the stress therefore was greater. The range of motion in the case of ordinary electromagnets was extremely limited, and could be measured by 10ths or even 100ths of an inch. That was due simply to the smallness of the stress when any considerable thickness of air had to be passed. This disadvantage was so considerable that the late Robert Stephenson in 1866 gave this as a reason why electricity could never compete with steam power. He said that they might liken an electromagnet to a steam piston with an enormously large area of piston, but a very short stroke, which was very undesirable mechanically. The coil and plunger form of magnet had a much greater range of motion, but feeble average force, and was more analogous to the steam engine piston and cylinder. (Magnet shown in action.) Page constructed his motors on this principle in 1850. With a cylindrical plunger the length of the stroke and the distribution of the force between the beginning and end of the stroke depended not only upon the length of the tubular coil, but on the length and shape of the plunger. If the plunger was not greater than the length of the coil, it reached the position of maximum pull when it was immersed about half its own length in the coil. In all cases where a soft iron armature was used, the electromagnet was only single acting—that was to say, in mechanisms of this kind you must cut off the current to allow of the armature being pulled back by a spring. Exceptions to this rule were polarised mechanisms, wherein plungers or armatures which had been previously magnetised or were permanently magnetised were used. Such apparatus could be made double acting. Telegraph relays and single-ringing bells to work with alternate currents were examples.

To the electrical engineer the electromagnet with its armature constituted the central organ of all electromagnetic machinery. Just as the mechanical engineer studied indicator diagrams to ascertain what went on in the cylinder, so the electrical engineer must also use diagrams of a certain kind to enable him to trace the increased saturation of the iron core, ascertain its retentiveness, etc. Far as the analogies between the electromagnet and the steam engine had been traced, they might be carried one stage further. The principle of reversibility held good of the electromagnet as well as the steam engine cylinder. He did not mean the mere mechanical reversibility of function, but the very same mechanism was capable of serving the inverse function of employing mechanical power to compress steam or air. The pump was, in fact, the inverse of the steam engine. Its action was merely the action of the engine reversed. In the engine, heat was converted into work, or, in other words, entropy was let down from a high temperature to a low one, and furnished mechanical energy. On the other hand, energy furnished by a mechanical system was employed to transfer entropy from a low temperature to a high one, as in freezing apparatus. The modern dynamo was simply an electric engine, a combination of iron cores and copper coils capable of serving either as generator of currents, or mechanical motor worked by currents.

He must, however, return to the principle of the magnetic circuit, and restate it. The number of magnetic lines that would be evoked in any given circuit was directly proportional to the circulation of the surrounding electric current, and inversely proportional to the magnetic reluctance of the iron and air gaps of the circuit. It was usual to specify the circulation of the current in ampere-turns, meaning by that the amperes multiplied by the turns of wire in the coil. The reluctance of the magnetic circuit had to be calculated in separate parts, to be added together afterwards, allowance being made for leakage of magnetic lines. All known substances possessed permeability for magnetic lines, none having yet been discovered that were impermeable. Iron, nickel, and cobalt had a relatively large and variable permeability, unlike the vast majority of media, which had a constant and small permeability not differing sensibly from that of vacuum. Of the above-mentioned metals iron was the only one of importance, different specimens of which differed widely in permeability. Moreover, a sample of iron that had been well magnetised was much less permeable than one which had not been well magnetised—it became more impermeable the more it was permeated. Approximately the permeability of a specimen was proportional to the difference between the actual magnetic flux through it, and the maximum flux that could be forced through it. A specimen of annealed wrought iron when permeated with 18,000 lines per square centimetre was practically saturated, but at 17,000 lines per square centimetre had a permeability of 161, and at 16,000 its permeability was 320. The intensity of the magnetising force at any point, generally denoted by H, was often expressed by saying that it would produce H lines per square centimetre, if it was acting on an air core. If a core of iron was substituted for air, a larger flux of lines per square centimetre would be produced by the same magnetic force. This larger number expressed the degree of magnetisation of the iron, and was usually denoted by the letter B. The ratio of B to H expressed the permeabilty of the iron at that particular stage of magnetisation. To ascertain the magnetic properties of any specimen, a series of observations must be made with various values of H. In any complete observations, a number of such series must be made at different temperatures; as certain materials—notably alloys of iron and nickel—lately investigated by Dr. John Hopkinson changed their magnetic properties when heated. A series of observations made by Dr. John Hopkinson were represented by the curves in the diagram, Fig. 1.

Two liberties had been taken with this diagram. In the first place, the numbers plotted out were the numbers of magnetic lines per square inch, instead of per square centimetre. Secondly, the magnetic forces were plotted vertically, and the resulting induced magnetism horizontally, conversely to the usual method. The curve that started from 0 represented the set of observations made with magnetic forces, gradually increasing to about $H_{\prime\prime} = 170$, when the resulting number of magnetic lines per square inch in the iron was about 100,000. It would be noticed that when the magnetising force, $H_{\prime\prime}$, approached the value of 100, the curve became very steep, any further increase producing relatively little increase in the magnetisation.

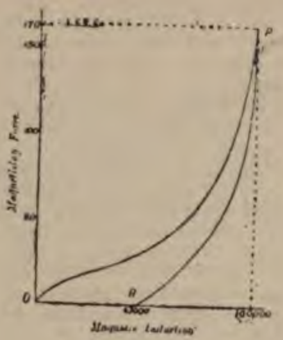


FIG. 1.

The second curve represented the result of their decreasing the magnetising forces back to zero, when there remained behind a residual magnetism of no fewer than 47,000 lines per square inch. To remove these would require the application of a reversed or negative magnetic force of about $H_{\prime\prime} = -13$. Applying the principle of the indicator diagram to these curves, it would be seen that the area below the first of them down to the zero line, and bounded on the right by the ordinate of the point P, represented the integral product of magnetic force into magnetisation, and was consequently proportional to the work done per cubic inch of the iron in bringing about the magnetic state of things implied by the position on the diagram of point P. Similarly, the area under the descending curve represented the work restored in the demagnetising of the specimen down to the state of things represented by the point R, when the magnetising force had been removed. The narrow area enclosed between the curves represented the work not so restored, and for the expenditure of which the residual magnetism was all there was to show. If the magnetising forces were carried through a complete cycle of alternations from $+H_{\prime\prime}$ to $-H_{\prime\prime}$ and back, the resulting magnetisation went through a corresponding cycle, with the result that a definite closed area was completed between the curves in the diagram, Fig. 2. Where there was no lagging in phase of the magnetisation behind that of the magnetising force, the ascending and descending curves would coincide instead of enclosing an area. The phenomena of lag had been studied by Prof. Ewing and Dr. John Hopkinson, to the former of whom was due the term hysteresis, to denote the lagging of effects behind the phase of their causes. Hysteresis was in magnetic what molecular friction was in elastic problems, always the cause of work being wasted.

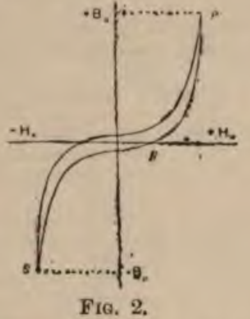


FIG. 2.

Prof. Thompson then proceeded to illustrate by a few experiments one or two of the principles of the magnetic circuit; showed Mr. Bidwell's experiment of the repulsion of two pendulums hung at either end of a hollow coil by the plungers inside it; referred to numerous electromagnets by Joule, Sturgeon, Froment, Houdin, Le Roux, Dub, etc.; alluded to electromagnetic tools, beginning with dentists' drills and Mr. Latimer Clark's device for divers to work on sunken ships, and passing on to the tools introduced and devised by Mr. F. J. Rowan, of Glasgow, magnetic separators, electromagnetic locks, etc.; and finished by defining the "electromagnetic engineer."

They would observe his use of the double adjective. There was no such thing as an electrical engineer pure and simple. What was wanted was an electromagnetic engineer, one who knew something about the way in which electricity worked magnets. To be able to make things electric-tight was more important than to be able to make things gas-tight or heat-tight, and more difficult. The art of insulation not only included a great deal of electrical, but also a great deal of mechanical knowledge. When they began to work from central stations that were not central but "excentric," they had to deal with great pressures needing high insulation to prevent sparks piercing it.

He had been trying to arrange electromagnetic mechanisms in some categorical order so as to arrive at connecting links. Prof. Willis, 40 years ago, and Prof. Roulan, of Berlin, 20 years ago, did this for mechanical mechanisms, and what had been done for them ought to and would be done for electromagnetic mechanisms. He had not yet succeeded in finding any rational classification. He had worked out a symbolism, and hoped to publish it some day, and then he might get a little more light upon the synthesis and analysis of electromagnetic mechanisms generally. But this kind of thing did not come down straight like an inspiration; it took years to work out. Systematisation was of the highest importance, however, because he felt certain that, great as were the advances that had been made, the systematic study of the theory of electromagnetic mechanism would lead them on to greater advances in the not distant future.

On the proposition of Mr. Wells, a very hearty vote of thanks was accorded to Prof. Thompson for his address.

NEW COMPANIES REGISTERED.

New Zealand Electrical Syndicate, Limited.—Registered by Beyroux, Phillips, and Golding, 99, Cannon-street, E.C., with a capital of £30,000 in £10 shares. Object: to acquire charters, concessions, privileges, and other grants for the manufacture and employment of electric lighting, etc., in New Zealand, Victoria, New South Wales, North, South, or Western Australia, Tasmania, New Guinea, and the Fiji Islands, and particularly to acquire the central stations for the supply of electricity erected by the Gulcher (New) Electric Light and Power Company, Limited, in the city of Wellington, New Zealand. The first subscribers are:

	Shares.
D. de Castro, 6, New-square, Lincoln's Inn	1
W. Turnbull, Mount Hanley, Sydenham	1
R. Pryor, 79, Gracechurch-street, E.C.	1
M. S. Vanderbyl, 187, Queen's-gate, S.W.	1
H. Grewing, 14, Austinfriars	1
J. Alexander, 3, Great Winchester-street	1
W. Farmer, 48, Aldermanbury	1

There shall not be less than three nor more than seven Directors. The first are D. de Castro, H. Grewing, M. S. Vanderbyl, and J. E. Williams. Qualification and remuneration not specified.

CITY NOTES.

Resignation.—It is stated that Mr. F. C. Bell has resigned the office of managing director of Bell's Asbestos Company, Limited.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Company for the week ended December 26 were £4,441.

Western and Brazilian Telegraph Company.—The traffic receipts of this Company for the week ending December 26 were £3,453.

Award.—Messrs. Day and Co., of London, have been awarded a silver medal for dynamo and fittings shown at the Western Counties Art and Industrial Exhibition, Plymouth.

Crossley and Son.—The Directors recommend a dividend of 10s. per share (less income tax), which, with the interim dividend paid in August last, is equal to 7½ per cent. per annum for the past year.

West India and Panama Telegraph Company.—The receipts of the Company for the half-month ended December 15 were £2,499, against £2,835. The August receipts, estimated at £4,950, realised £5,013.

Reuter's Telegram Company.—At an extraordinary general meeting of this Company on December 24, the resolutions passed at a previous meeting (*vide E. E.*, December 12) were unanimously confirmed.

Business Notice.—We are informed that the Eschweiler Wire Industry Company, Limited (Germany), manufacturers of wire rods, rolled and drawn wire, wire nails, etc., have appointed Messrs. Künster and Co., 11, Queen Victoria-street, E.C., their sole agents in this country.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	2
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	7½

NOTES.

The Brentford Guardians have provided telephonic communication between their schools and the workhouse.

Westminster Supply Company.—This company hope to supply current from their Davies-street station by next March.

Sweden.—At Ballnoos in Sweden a waterfall is utilised to drive the machinery for supplying current to 400 incandescents of 16 c.p., used for public and private lighting.

Death.—Prof. Casey, LL.D., F.R.S., Fellow of the Royal University of Ireland, died in Dublin on Saturday last. He was 70 years old, and a distinguished mathematician.

Telephone in Lincolnshire.—Telephonic communication is about to be opened up between Lincoln, Gainsborough, and Doncaster, by the National Telephone Company.

Gravesend.—The Town Council last week discussed the present unsatisfactory condition of the public lighting in the town, and strongly condemned the supineness of the gas company.

The Tory Island Cable.—A telegram from Lloyd's signal station at Tory Island, dated Dunfanaghy, January 4, states that Lloyd's Tory Island cable has been thrown open to the public.

Derby.—The Town Council have decided to obtain a report from Sir Frederick Bramwell on the subject of electric lighting for the town under the Derby order, at a cost of 75 guineas.

Reform Club.—The contract for the fitting up of the Reform Club has been given to Messrs. Verity and Sons. The installation is to comprise 500 lights, and the current will be supplied from the St. James's and Pall Mall central station.

Brush Lights in the City.—The Brush Electrical Engineering Corporation have taken the corner near the Mansion House Station, 55, Queen Victoria-street, as their offices and central premises for the City lighting enterprise.

The Andaman Islands.—The Meteorological Reporter to the Government of India has recorded his opinion that it is almost absolutely necessary for the warning of the Bengal and Madras coasts that a cable to the Andaman Islands should be laid.

Dewsbury.—The Town Council propose to spend £50,000 in carrying out electric light works under their order; this is estimated to be considerably more than will be required for the compulsory area, and sufficient to deal with extensions in the future.

Holland House, Kensington.—The Wenham Company have obtained the contract for the lighting of Holland House, the residence of Lord H. Chester. This company, it may be remembered, carried out the lighting at Craig-y-Nos Castle, for Madame Patti.

Dublin.—We understand that the committee of the Corporation of Dublin have recommended the tender of the Electrical Engineering Company of Ireland for acceptance. The decision has not been definitely announced, but official recognition will doubtless follow.

Appointment Vacant.—An assistant mechanical engineer is wanted for the Government powder factory at Ishapore, India. He must be efficient in electrical engineering. The salary and other particulars will be found in our advertisment columns.

Appointment.—Mr. M. C. Olsson, who was associated with Mr. Massingham for three years in his electrical works at Taunton, and for the past two years has been chief electrical engineer of some large works on the Continent, has been appointed to take charge of the Bath central station.

Northampton.—The Council have decided that a contract upon the same terms and conditions as applied to the western portion of the new Town Hall Municipal Buildings be entered into with the Northampton Electric Light Company for the electric lighting of the remainder of the buildings.

Calendar.—Messrs. Appleton, Burbey, and Williamson, of 91, Queen Victoria-street, E.C., send us a novel calendar for office use in the shape of a porcelain slab, the lower half of which is roughed for pencil memoranda, while the top half contains the calendar, with revolving date plate for weekly adjustment.

Companies Wound Up in 1890.—The following companies were wound up voluntarily during the past year: Australasian Electric Light, Power, and Storage Company, Maxim-Weston Electric Company, Whitehall Electric Supply Company, Woodhouse and Rawson Electric Contract and Maintenance Company.

Barnsley.—The Town Council are advertising for tenders for erecting their central station buildings, which will be situated in Midland-street and Queen's-road. Mr. J. H. Taylor, A.M.I.C.E., of St. Mary's place, Barnsley, is the architect, and tenders are to be sent in to him not later than 3 p.m. on the 16th inst.

Electric Traction in Sweden.—An electric tramway is about to be run in Stockholm, and one is also projected between the towns of Karlsland and Orebro. The mines in the district of Vormland are supplied with electricity both for lighting and power purposes, the generating machinery being driven by water power.

Kensington Town Hall.—An inauguration of the electric light at Kensington Town Hall was held yesterday evening in the shape of a *conversazione*. The lighting comprises several hundred electric lamps installed by Messrs. Baily and Grundy, the current for which is supplied from the Kensington and Knightsbridge Company's station.

Books Received.—"Electric Transmission of Energy," by Gisbert Kapp, C.E., third edition, revised, "The Specialist Series"; published by Whittaker and Co., 2, White Hart-street, Paternoster-square, E.C. "Electric Light Installations and the Management of Accumulators," Sir David Salomons, A.I.C.E.; sixth edition, revised and enlarged, same publishers.

Lectures.—Prof. W. E. Ayrton, F.R.S., will give a course of lectures on accumulators, electric lighting, electric traction, and the distribution of energy at the Central Institution of the City and Guilds Institute, on Mondays and Wednesdays, from 3 to 4 p.m., beginning next Wednesday, the 14th inst. Further particulars will be found in our advertisement columns.

Institution of Electrical Engineers.—The next meeting of the Institution will take place on Thursday, the 15th inst., when the president, Mr. W. Crookes, F.R.S., will deliver his inaugural address. On and after the 25th inst., the address of the Institution will no longer be 4, The Sanctuary, but Victoria Mansions, 28, Victoria-street, Westminster, S.W.

Messrs. W. H. Willcox and Co., of Southwark-street, S.E., send us their office calendar for this year, which is clearly printed in coloured inks, and besides affording the usual information as to dates, also has some neat illustrations of their manufactures, which comprise belting, piston packings, cylinder and dynamo oils, engineers' sundries, etc.

Madras.—The *Madras Times* hears that a gentleman who has arrived in Madras from England has submitted a scheme to the President of the Municipal Commission for lighting the city by electricity, and running electric tram-cars in it. He is supposed to be powerfully backed at home, and one of the promoters is in India negotiating with the authorities concerned.

Edinburgh Exhibition and Mr. Bapty.—On Tuesday, in the Edinburgh Court of Session, Lord Stormouth-Darling closed the record in the action by the liquidator of the Edinburgh Exhibition against Samuel Lee Bapty, the general manager of the exhibition, in which decree is asked for the sum of £500 which defender guaranteed to the funds of the exhibition.

Prague Exhibition.—It is proposed to hold an International Exhibition in Prague from May to October next. A section is to be devoted to machinery for the prevention of accidents, two of the groups in this section being devoted to transport and lighting, ventilation and fire-engines. Applications will be received by the Executive Committee, 55, Wenzelsplatz, Prague, up to the 31st inst.

Panama.—A French journal states that the Municipal Council of Panama has signed a contract for the fitting up of 43 arcs for street lighting. The company who are doing this work have also received orders for 300 incandescents for private lighting. We hope that electric lighting will fare better than the other enterprises with which the name of Panama is connected, but we have our doubts.

Theatre Lighting.—The electric installation at D'Oyly Carte's new theatre is now finished and in thorough working order. The theatre will be opened with considerable flourish of trumpets in about three weeks' time, and not the least successful of its many well thought out details is the very extensive electrical and steam engine arrangements which have been carried out by Messrs. Verity and Sons.

Owens College.—The following elections to fellowships have recently been made by the council for the year 1891. Bishop Berkeley Fellowships: W. R. Ormandy, in chemistry; and renewed for a second year to P. J. Hartog, B.Sc., in chemical physics. Honorary Research Fellowships: Gibson Dyson, Ph.D., in chemistry; J. L. Hoskyns Abrahall, B.A., Ph.D., in chemistry; C. H. Lees, M.Sc., in physics.

Diary for 1891.—We have received a copy of the pocket diary issued by the Eastern Telegraph Company. It contains a list of cable rates to different parts of the world, a calendar and diary, and several very well got-up maps of the cable systems of the world with their overland feeders. We have also to acknowledge the receipt of a useful paper knife, the blade of which carries a cable map and the handle a calendar.

Agra Water Works.—These works were opened by the Viceroy of India last month. The boiler-houses, engine-houses, pump-room, and purifier-room are lighted with 16-c.p. lamps. The machinery connected with the pumping and purifying of the water and the electric light has been supplied by Messrs. Easton and Anderson, Limited, of Whitehall, and has been erected by the contractors, Messrs. Marillier and Edwards, of Calcutta.

Dr. Stephan, the German Postmaster-General, celebrated his sixtieth birthday on Wednesday, and received from the Emperor William a photograph of himself, at the foot of which His Majesty wrote the following: "Intercommunication is the sign under which the world stands at the close of the nineteenth century. It breaks down the barriers separating one people from another, and establishes new relations among the nations of the earth."

Limerick.—It will be remembered that the Limerick Corporation allowed their application for an order to drop, so far as this session is concerned (*vide* our list of provisional orders applied for, *E.E.*, Dec. 26, p. 576). Now, however, they have been urged into action again by the desire of the Irish House-to-House Company to invade the town. Accordingly the Corporation have recently determined to apply for an order with the view of keeping the company out.

Telegraph Work in India.—Putting up lines in India is not all beer and skittles, as will be seen from the following: "There has been much sickness among the telegraph party working between Kan and Haka, the men employed on this section of the line having suffered in common with the Haka garrison from epidemic fever. On the Chittagong side the death from fever is reported of Mr. R. Rector, sub-assistant superintendent, an officer of great energy and resource."

Electrical Advertisements.—Outside the Pavilion Music Hall, in Piccadilly, a large electric sign has been fitted up with the word "Pavilion" in large glass letters. By an automatic arrangement the colours of the illumination are made to change every half minute. The idea is one that might be adopted in many situations where a prominent advertisement or notice is required, as one of the first facts to be remembered by advertisers is that anything moving or changing is far more attractive than a simple sign.

Mexborough.—At Wednesday's meeting of the Local Board, it was proposed that the electric light should be introduced. The total cost of the works was estimated at £2,055, and the annual expenditure would be about £300, including the services of an electrical engineer. The chairman (Mr. Tiptaft) said he was so satisfied with the electric light that he should strongly oppose the erection of new gas works. The electric light was an assured success, financially and otherwise. A definite scheme is to be laid before the next meeting of the Board.

Spiers and Pond.—As we mentioned some weeks ago, a large installation has been put down by Spiers and Pond, Limited, at their new premises in Water-lane, Queen Victoria-street, E.C. The offices and bakeries are lighted by some 300 lamps, and the market street in Water-lane by 22 arc lamps. The Holborn-viaduct Hotel is supplied from the same source by cables run along the railway, and 800 lamps are lighted in this hotel. The arcs make Water-lane, hitherto a somewhat gloomy thoroughfare, a really well-lighted and pleasant street to get about in.

Bridlington (Yorks.).—At a meeting of the Local Board on Tuesday, a joint committee of the members of the Prince's Parade and Lighting Committees, appointed to consider and report as to the best means of lighting the Prince's Parade during next summer, reported that, after going fully into the matter, they recommended that the walks and terraces be lighted by means of electricity, and colonnades, lavatories, etc., be lighted by gas, and that the committee visit certain districts where the electric light is in use, and further report as to the best system to adopt. After discussion the report was adopted.

London University.—The following passed the recent examinations for B.Sc. in experimental physics. First class: William Watson, scholarship, Normal School of Science; Alfred W. Porter, University College, Liverpool and

London; Owen G. Jones, City Guilds Central Institute. Third class: Harry E. Hadley, Arthur R. Hall Ingram, Mason College, Birmingham; Thomas P. Nunn, University College, Bristol; George A. Schott, Trinity College, Cambridge; Walter Thorp, Yorkshire and University Colleges; John T. Hewitt, Hartley Institute, Normal School of Science, and St. John's College, Cambridge.

Whipple's Reports.—We have received a copy of the December issue of these reports. In commenting on the way business has been conducted in the past and forecasting the future Whipple says: "There are already indications that electric companies are demanding shorter time on payments of their goods, that more of the legitimate and less of the wildcat sort of competition will be seen in the future, and that better business principles will be instilled into the methods of selling goods. Therefore out of the present evils will come good, and the electrical business will be more than ever one of the great trade institutions of America."

Electrical Bleaching Processes.—At a meeting of the East of Scotland Engineering Association, held at Edinburgh this week, Mr. J. B. Bennett, C.E., read a paper on "Papermaking Processes and Machinery," in which, after dealing with the historical development of paper manufacture, he referred to the materials and methods used in modern times. He described in detail the electrical processes which are being introduced for bleaching paper pulps, as well as textile fabrics, by which solutions, such as sea water, containing alkaline chlorides may be used for bleaching, and gave particulars of the preparation of wood pulps, which are now so largely used by papermakers.

The Sonnblick Observatory.—The death is announced of Herr Ignaz Rejacher, owner of gold mines at Kulm Saigurn, in the Rauris Valley, and originator of the Sonnblick Observatory, the most elevated in Europe. He commenced life as a peasant, but eventually became one of the chief promoters of science in Austria, and a great benefactor of the district in which he resided. The observatory is tenanted by a peasant who formerly worked in the above mines. During several months of the year he is, by the difficulties of his situation, cut off from personal association with the world, except by telephone. He hears each day living voices through this instrument, but otherwise he is isolated, and has only a dog for companionship.

New Continental Companies.—The Anglo-Austrian Bank of Vienna, and the firm of Siemens and Halske, of Berlin, have just formed three new electrical companies with headquarters in the former city. The first is the Austrian General Electricity Company, constituted, with a capital of £312,000, for the purpose of constructing and working central electric light stations. The second is the Electric Tramway Company, with a capital of £312,000, for the making and working of electric tramways, and the company have already acquired the Buda-Pesth electric tramway. The third is the International Compressed Air and Electricity Company, with the same amount of capital, and formed to work a concession obtained from the Vienna municipality for lighting the city by electricity.

The Telephone in Reading.—A local paper says: "The popularity of the telephone has much increased of late years in Reading under the present excellent management. There are no fewer than 181 connected with the exchange, and several other private residences and business establishments are shortly to have telephonic communication. There are also several private wires. The trunk line which will connect Reading with London is being rapidly pushed forward, and will probably be completed this year. There is practically a connection from London to Bracknell, and the line from the latter place to Wokingham is being constructed, while the necessary permission has been obtained to carry the wires to Farley, which is now the limit of the Reading centre in that direction."

Fire.—At 4.45 a.m. on Tuesday, the 6th inst., a fire broke out in the works of the Electrical Engineering Corporation at West Drayton. The outbreak was discovered by the stokers, who were getting up steam in the main fitting and machine shop. Two hydrants belonging to the company were got to work within a very short time, and efforts were made to keep the fire in check. This, however, proved to be beyond the powers of those present. The water supply was therefore utilised to save the adjoining buildings, and with success. The shop in which the fire originated was practically gutted, the damage being estimated at about £15,000, which is covered by insurance. We are assured by the managing directors of the corporation that the fire will not interfere with the execution of orders in hand, or that may be entrusted to them.

Conversazione.—On Tuesday next the Birmingham Midland Institute holds its annual *conversazione*, which promises to be very successful. Among the exhibits promised are: The Giffard gun, lent by the Giffard Gun Company; steam loop, an arrangement by which the exhaust steam from an engine can be returned to the boiler; lecture-room model of Sir William Thomson's quadrant electrometer, exhibited by Mr. G. W. Holbrook; Dr. Lodge's Leyden jar experiment, exhibited by Dr. Poynting, F.R.S.; photographs showing oscillatory discharge of a Leyden jar, lent by Mr. C. V. Boys, F.R.S.; mechanical designer—for producing a variety of designs by mechanical means, invented and exhibited by Mr. F. Iles, Highgate-street, Birmingham; also a newly-patented accumulator, invented by Mr. Drysdale, one of the institute students. Telephones will be provided by the National Telephone Company in connection with public performances in distant towns.

Birmingham and Midland Institute.—The report of the council of this institute states that Mr. G. S. Albright has added another to the many obligations under which the institute lies to him, in generously providing an installation of electric lighting in the metallurgical department. Formerly the laboratory, when all its furnaces and muffles were alight, and the place full of students at work with hot metal, the light they required being given by a free use of gas, became almost dangerously hot for those in it. We also learn from the same document that among the old students who have obtained appointments are Mr. W. P. Wynne, who has been made assistant professor at the Royal Norman School of Science, South Kensington; Mr. W. Tate, who has charge of one of the laboratories there; while yet another—Mr. A. E. Briscoe—has been appointed assistant to Profs. Thorpe and Rücker in their researches as to the local variations of the magnetic elements in different part of England.

Leeds.—At last Wednesday's meeting of the Leeds County Council, the town clerk (Sir Geo. W. Morrison) reported the receipt of plans and parliamentary notices, under the Electric Lighting Acts, 1882 and 1888, from the National Electric Supply Company, the Yorkshire House-to-House Company, and the Electric Installation Company. The Yorkshire Company, he said, proposed to light the whole borough; and the other two companies were seeking powers to supply electricity in the centre of the town. Ald. Harrison explained that the Council, after the decision they came to a few weeks ago not to supply electricity themselves, were in a different position from that in which they found themselves when similar notices last came before them. It was necessary that any objections to the notices should be submitted to the Board of Trade by the 15th of the present month. No detailed action would be necessary; but he proposed that the matter should be put into the hands of the Parliamentary Committee, so that a technical objection might be made. The Corporation would then have a *locus standi* on a future occasion. After some discussion, this suggestion was agreed to.

The Comprehensive International Wire Table. Mr. W. S. Boult has compiled and published a book containing a very comprehensive series of tables relating to wires. These tables are clearly printed and occupy some 50 pages. They relate to the diameter, area, gauge, weight. current, resistance, heat when cased, and heat when bare. The wires about which this information is tabulated range from 2·26in. to ·001in., altogether 469 different wires. Use has been made of the Silvertown tables, and of assistance rendered by Messrs. Glover and Co., and Kennelly's formulæ have been employed to calculate the heating of the wires. It might be worth while asking if Mr. Kennelly's formulæ have been generally or authoritatively adopted. We had supposed that at present such was hardly the case, and that doubts have been in more than one quarter expressed as to their accuracy. The figures, however, relating to heat form but a small proportion of the whole, and even if the formulæ be adversely criticised they certainly are sufficiently accurate in most cases for practical work. Altogether these tables should prove extremely useful and valuable, and Mr. Boult is to be congratulated on their production.

Institution of Civil Engineers.—On Friday last this institution reached its seventy-third anniversary, having been founded on the 2nd January, 1818. At this latter date six young men associated themselves together for mutual advantage, and from this small beginning sprang the present powerful institution. The presidents of the institution have been, successively, *Thomas Telford*, *James Walker*, *Sir John Rennie*, *Joshua Field*, *Sir William Cubitt*, *James Meadows Rendel*, *James Simpson*, *Robert Stephenson*, *Joseph Locke*, *George Parker Bidder*, Sir John Hawkshaw, *John Robinson McClean*, Sir John Fowler, Bart., K.C.M.G., Sir Charles Hutton Gregory, K.C.M.G., *Charles Blacker Vignoles*, Thomas Hawksley, *Thomas Elliot Harrison*, George Robert Stephenson, *John Frederic La Trobe Bateman*, William Henry Barlow, James Abernethy, Lord Armstrong, C.B., Sir James Brunlees, Sir Joseph William Bazalgette, C.B., Sir Frederick Joseph Bramwell, Bart., Edward Woods, and Sir George Barclay Bruce. The names in *italics* indicate those who are no longer living. The present president is Sir John Coode, K.C.M.G. The number of the various classes now on the books comprise 1,700 members, 2,880 associate members, 427 associates, 19 honorary members, and 927 students, together 5,953.

Leith.—At the meeting of the Town Council on Tuesday the minutes of a special meeting of the General Committee, held on December 30, showed that the committee had considered the Edinburgh Corporation electric lighting order, and had "expressed the opinion that if the Corporation of Edinburgh are to obtain such powers it should only be under the most ample protection to this burgh from any loss in the matter of the gas supply; and particularly that the proposed power to transfer the operation of the order to the Gas Commissioners, thereby making these Commissioners (involving the rates of Leith) financially responsible therefor, should not be effectual without the consent of the Corporation of Leith; and that there should be provision for any increase in the price of gas, or other loss in connection with the gas supply, being borne alone by Edinburgh, who are introducing the competitive light." The town clerk read the minutes of a meeting of the committee held on the same day as the Council meeting (Tuesday), in which was stated that the minute of the committee dated December 30 last had been amended to the effect that the proposed "loss clause" should only take effect in the event of the electric lighting order being administered otherwise than by the Edinburgh and Leith Gas Commissioners, with the consent of the Corporation of Leith. These minutes were agreed to.

Cambridge.—The Town Council at the last meeting decided to obtain powers to borrow £35,000 for electric lighting purposes. Although powers to borrow £35,000 are to be obtained, it is thought that a complete installation will cost from £20,000 to £22,000, such as will supply 3,000 incandescents of 16 c.p., which would allow 6,000 lamps to be wired, and 60 arc lamps of 1,500 c.p. for street lighting. Reference during the discussion of the question was made to the Bradford installation balance-sheet, which showed, allowing interest on outlay, £700 loss on three months' working; without interest, £11 profit; but this arose because Bradford only charged to customers 5d. per unit, a price admittedly too low, and in future Bradford would charge 6d. per unit, while Cambridge proposes to charge 8d. per unit. Any comparison of such charges must consider the difference in cost of coal for engines at Cambridge and Bradford. While the latter may make a fair profit the former could not at the same price. The gas company at Cambridge met the agitation for electric light by reducing the price of gas by 2d. per 1,000, showing their fear of the competition. Without doubt one consideration must be taken into account when making plans for electric lighting, and that is, to provide from the first for extension that shall enable the whole town to be supplied.

Preston (Lancs.).—At a recent meeting of the Town Council Alderman Birley, referring to the approval given by the Streets and Buildings Committee to the erection of several electric lights in various parts of the town, asked for some information upon the general subject of electric lighting. He hailed with great pleasure the introduction of the electric light, but he was afraid the gas company were not alive to its importance, or they would try to please their customers by supplying better light than at present; a remark which evoked unanimous expressions of approval. The town clerk, in reply to Alderman Birley, said that during the last session of Parliament there were two orders promoted. One was by the National Electric Lighting Supply Company, but they only dealt with a portion of the town, such as Fishergate, Friargate, Lune-street, Church-street, Market-place, and Lancaster-road. The other company, which got an order for the whole borough, was the Lancashire and Cheshire House-to-House Company. When the order of the National Company was going through it was made a condition by the Corporation that that company should in the coming session promote an order for the rest of the town, the object being, of course, to create competition. If the National Company did not go in for that order this session, it would leave a great portion of the town in the monopoly of the Lancashire and Cheshire Company. The order which Alderman Birley had seen advertised was to obtain that competition.

Birmingham.—The Birmingham Electric Light and Power Company is progressing with the work of supplying electricity within its area. The amount of work yet to be done in the streets is comparatively small, the laying of the buried heavy mains having been completed some time since, and during the last few days men have been busy at the manholes, threading through the culverts prepared for their reception the copper strips which form the lighter distributing mains. Not much of this work remains to be done. At the generating station in Albert-street fair progress is being made. The boilers are set, and the fixing of the engines is proceeding; but some portions of the work are at a standstill owing to the frost, which has made bricklaying difficult, and has absolutely stopped one essential part of the work—the completion of the chimney-stack. In the meantime every operation which the weather does not hinder is being pushed forward, and it appears likely that nothing but a serious prolongation of the frost will stand in the way of the fulfilment of the anticipation that the electric light will be in use by the end of this month. Orders for over 2,000 lights have been received, and this is considered very good for a company that has not yet commenced. The work already done by the company includes a large amount in the "wiring" of premises which are to be lighted, such as the Victoria Courts, the Grand Hotel, the Bank of England, Temple-row (premises of the late Staffordshire Joint-Stock Bank), the new building of the Prudential Assurance Company, in Corporation-street, and the Alliance Insurance Company's offices.

Newcastle-on-Tyne.—The application by the Newcastle Electric Light Company for the Town Council's sanction to an extension of the period covered by their order from seven to 42 years, came before the Council for decision on Wednesday, and gave rise to a lengthy discussion. Alderman Winter moved a resolution that the Council's consent be given, contending that they ought to afford a trading company all the facilities they could for lighting the town. He also mentioned that the company's charge for street lighting was 2d. less than that made to other consumers. Mr. Matthewson seconded the resolution. Mr. Temple said the application for the license was only a few months old, and the company knew then as much as they knew now. They got a license for seven years, and their only reason for seeking an extension of time was that they said they could not raise capital. Before the Council passed such a resolution, it required a great deal more careful consideration than it was likely to get there that day. A period of 21 years was quite long enough to let such a thing out of their hands without being able to alter it. He would move that the utmost limit of the granting of the license should not exceed 21 years. The Mayor said such a motion was not in order, and, after some further discussion, Mr. Temple formally moved that the meeting be adjourned for a month to enable the Council to negotiate with the company as to the length of period and the charge for the electric light. This was seconded. Alderman Hamond objected to a license being given for an indefinite period, which was virtually a monopoly, to any company. He was in favour of granting a license to the company for 21 years, but he thought that there should be a sliding scale to regulate the price, as with the gas company, according to the dividends. The consumer should have a share of the profits, as well as the producer. Alderman T. Richardson supported the adoption of Mr. Winter's resolution, wishing to promote the progress of science in the city, and the interests of the inhabitants. Mr. Temple had said that the company knew at first as much as they did now. They did nothing of the sort. It was a pure experiment then. They found now that they were obliged to lay down more extensive plant, and people would not go into a concern with such an insecure tenure. There was no monopoly. There was nothing in the provisions to prevent the Corporation from starting an electric supply on their own account. He hoped the Council would not stand in the way of progress in the city. The Council then divided on Mr. Temple's amendment that the matter be adjourned for a month, and it was carried by 31 votes to 18.

Practice in America.—Mr. C. E. Woods, writing in the *Electrical World*, says: "In reading the different papers devoted to the electrical interests, one cannot help noticing that most of the matter published in them bears upon the theoretical side of the question, and that very little space seems to be given to the plain, common everyday side of it. Now, while theorising is necessary, it should be remembered that in addition to theoretical problems we have some very practical ones to solve, and I will try to present some of them in this article, taken from the standpoint of a constructing electrician, which is my humble vocation, and I think my brother engineers will say I am right. While I lay no claim to being an electrical expert, I have had considerable experience in construction work, and I am sorry to say my work comes a long way from being satisfactory to myself for reasons that I will present later on. First, what is a constructing electrician or electrical engineer? He is the medium through which electricity in its various forms is introduced to an ignorant public. He is the one who must put into satisfactory operation the electric plants for light and power purposes. He is the one who must carry out the plans of half a dozen different men to obtain the desired result. He must learn when to take care of and operate his system, whatever it may be. He must be ready for any and all emergencies, and is supposed to be infallible; but in this respect it sometimes proves to be a case of misplaced confidence. But, poor fellow, he has much to contend with, and much trouble that is not of his own making, and the greatest of all is the everlasting desire of the American public for cheapness. This is a practical problem that some of the great and learned minds ought to endeavour to solve. It may be asked, What do you mean by cheapness? I mean the cheap material, cheap workmanship, and cheap labour that electrical engineers are obliged to use. We have as good material in our market as could be desired, but people won't pay for it—at least, as long as they can help it. I saw an article not long since in one of our leading papers telling how much better the material and work were in England than in America. Now, America has just as good material as can be procured, but American people won't pay for it as long as they are allowed to use cheap material, and just as long as the consumer can say what he shall pay and what kind of material shall be used in his particular installation will the electrical engineer be obliged to do poor work and use poor material. To be sure, the insurance companies have taken it up to a certain extent, but of a truth it doesn't go very far. And so to sum it up, in short, inside wiring in this country is, generally speaking, more a matter of dollars and cents than good work and material. I would suggest that if people will not do any different of their own accord, some means ought to be devised by which they will be forced to. If the insurance companies cannot enforce it let someone introduce a Bill carrying with it a set of rules and regulations for this purpose into the Legislature, and see if something cannot be accomplished in that way. Now when it comes to line work it is something dreadful to think about. There are absolutely no rules relative to this branch of the work that can be enforced, except in some few local instances; and of all the cheap unsightly work that ever was done the average line construction of to-day is, I believe, the worst. It comes of course from close competition between the various systems in some instances, but not always, for often local companies put up their own line work under the supervision of a man who knows little or nothing about it, hoping thereby to save something. But by so doing they make a grand mistake, which they sooner or later find out to their sorrow. This state of things will exist as long as local companies and manufacturers of different systems can pursue their individual methods in the matter."

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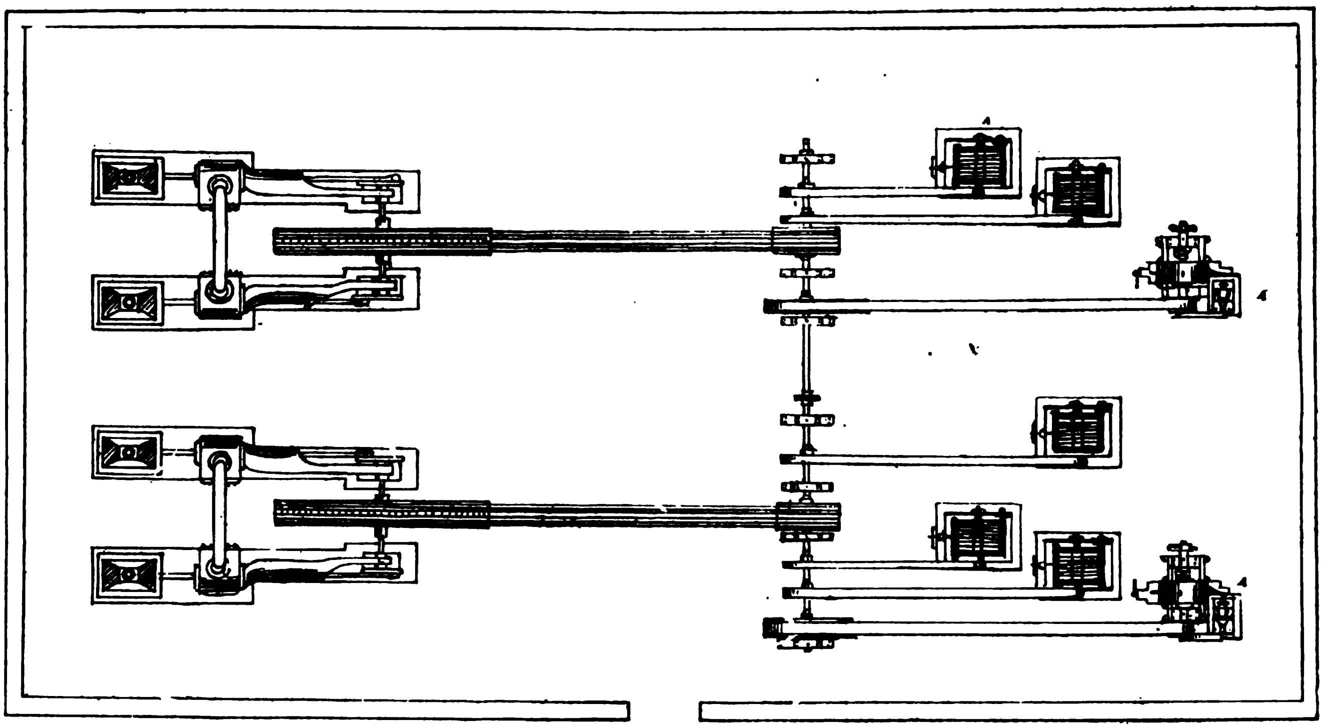
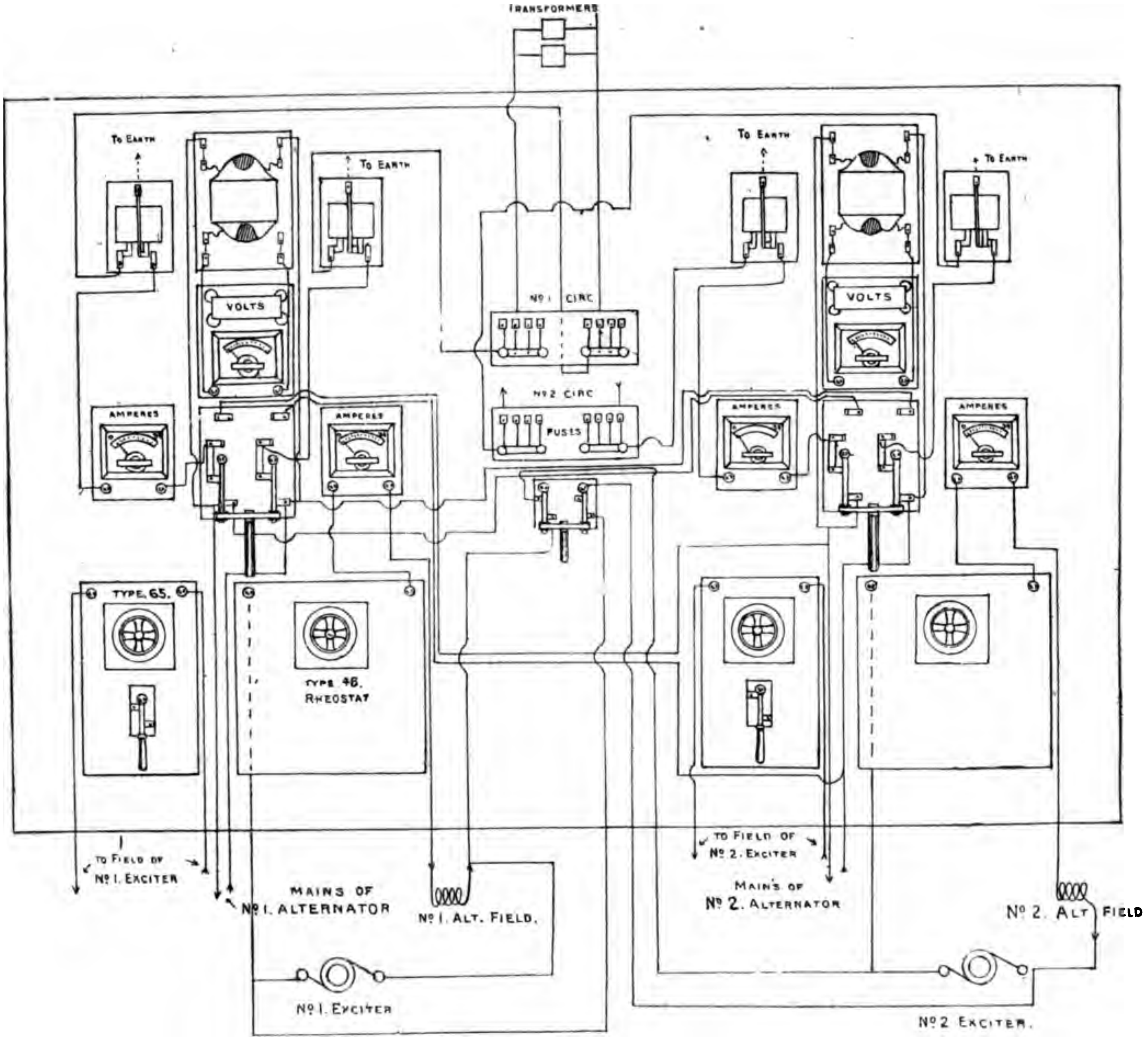


Plan of Engines and Dynamos—Kidderpore Installation.



Main Switchboard—Kidderpore Installation.

The contract for lighting the new docks at Kidderpore, near Calcutta, has been placed in the hands of the Laing, Wharton, and Down Construction Syndicate, for whom, we believe, Mr. Hitchcock, their engineer, is about to proceed to India in order to superintend the erection of the plant. The illustrations given herewith show the arrangement of the apparatus, so far as dynamo-room and engine-house is concerned. The switchboard is also illustrated, and will be seen to be well arranged. The plant consists of two coupled horizontal long-stroke condensing engines, two Lancashire boilers, built by Messrs. Ransomes and Co., of Ipswich. The engines drive a length of steel countershaft by means of rope gearing. The pulleys on the countershaft are all fitted with a new patent friction clutch, designed, we believe, by Mr. A. Guy, so that any machine can be stopped or started as required. There are in all seven dynamos driven from the shaft, five of which are Thomson-Houston arc machines, the other two are Thomson-Houston composite field (self-regulating) alternators. These machines will supply current to 51 arcs of 2,000 c.p. on wrought-iron poles, and six portable arcs to be used in loading and unloading operations, also 800 incandescents of 16 c.p. distributed in the various offices and storerooms. The latter are run from transformers. The mains are underground, principally run through subways, which already exist for the hydraulic mains. Some 30 miles altogether of okonite-covered wire will be used, about half of this being wanted for external work and the remaining half for internal work. We shall have to refer to the details of this installation in further issues, and trust that it will be the forerunner of much similar work in India and our colonies.

ON THE THEORY OF COMPOUND WINDING FOR CONSTANT POTENTIAL.*

BY DR. LOUIS BELL.

I wish to preface this paper by stating that there is in it nothing revolutionary, nor any radically novel attempt to treat a problem that has already been handled by more skilful hands than mine. It is simply an effort to bring the theory of compound winding to a practical basis, indulging in no complicated formulæ, and introducing no constants that cannot be conveniently determined in practice. To this end I shall consider the subject synthetically rather than analytically, starting from the plain shunt winding, and considering those terms which must be introduced to take account of the failure of shunt winding to give constant potential. I do not think that compound winding should be considered as anything more than a method of improving a shunt machine already well designed; it should certainly never be called upon to avoid the evil effects of bad design.

For the systematic treatment of the subject I would introduce the following notation, which differs slightly from that most often employed, but is convenient for the purpose in hand.

Let C_x, represent the current on the line;
C_s, the current in the shunt coils;
R, the resistance of shunt coils;
r, the resistance of armature and series coil combined;
E, the E.M.F. of the machine running light;
e, the fall of potential due to armature resistance;
N, the number of convolutions in shunt coils;
n, the number of convolutions in series coils;
m, the number of convolutions on armature;
a, b, c, the three terms of n;
l, the angle of lead;
q, the magnetic resistance of machine on open circuit;
q_x, the magnetic resistance of machine at full load; and
p, the value of q_x divided by q.

I shall consider especially the long shunt arrangement, though, as will be seen later, the short shunt leads to practically the same results.

The first and obvious cause of fall of potential at the terminals of the machine is due to the fact that the armature has a resistance; as the current increases a certain amount of potential is absorbed in the armature, and consequently the available E.M.F. at the terminals fall. The amount of decrease is evidently proportional to the resistance in the armature and the current through it.

$$e = r\,C_x.$$

To compensate this loss we must furnish an increase of induction sufficient to produce e additional E.M.F. If the field magnets and the armature core were quite unsaturated—that is, if we could neglect the change in permeability—we should simply increase the total ampere-turns to an amount sufficient to compensate the fall in potential. Let a be the series turns capable of producing this at full load, neglecting change in permeability, then

$$a = \frac{\mathrm{N}\,r}{\mathrm{R}}.$$

But the permeability decreases as we put on this additional induction. The magnetic resistance, q, at the start, will have increased to a certain other value, q_x. We must therefore increase the number of series turns to take account of this added resistance, and we have

$$a = \frac{\mathrm{N}\,r}{\mathrm{R}}\,p.$$

It will be observed that this quantity does not have to be multiplied by the coefficient of leakage because we have simply reduced the shunt turns to equivalent series turns, and consequently have already included it. This formula will be at once recognised as practically equivalent to that given by Thompson in his well-known book, and at this point Thompson drops the investigation, merely mentioning incidentally some of the other causes which necessitate compounding. Thompson's formula:

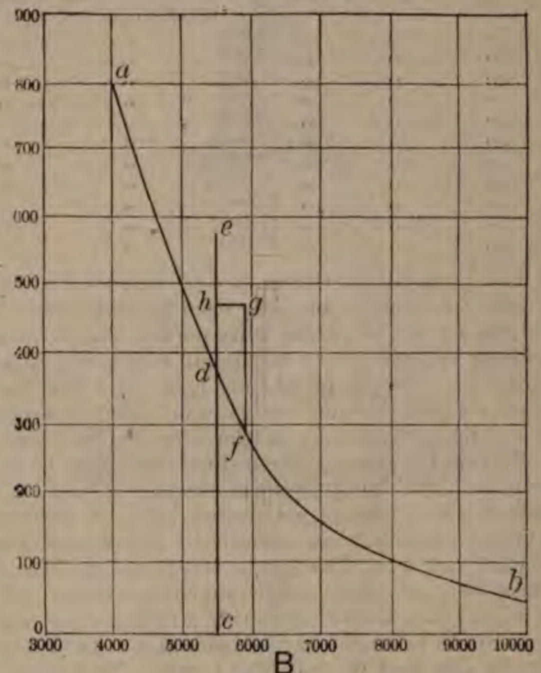


FIG. 1.

$$\frac{\mathrm{Z}}{\mathrm{S}} = \frac{r_s}{r_s + r_m} \times \frac{q_1}{q_0}$$

is not quite the same as mine, for the reason that while his q_0 is proportional to the permeability when there is no external current, his q_1 is proportional not to the permeability at maximum current, but to the mean permeability between no load and full load. Hence, if Z is taken as the number of shunt turns required to give the desired potential on open circuit, Thompson's formula will inevitably give too few series turns for the reason just mentioned, if for no other. But since by adding series turns the magnetic resistance is increased, the shunt winding which produces E volts on open circuit will not do so at full load. Additional series turns must then be employed to compensate for this, and since the change in shunt ampere-turns must be from N C to N C p, the number of series turns to be added to compensate for the decreased effect of the shunt will be

$$b = \frac{\mathrm{N\,E}}{\mathrm{R}}\,(p - 1).$$

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* A paper read before the American Institute of Electrical Engineers, New York, November 18th, 1890.

This term also includes C_x co-efficient of leakage for the same reason as before.

It will be noticed that both A and B include the quantity p, and here is met the principal difficulty in effecting the compounding. It is my purpose to show that this quantity p can be obtained from known data with sufficient accuracy for the purpose in hand. It will evidently be a quantity little in excess of unity, and in practical machines may range from 1·05 to 1·50, although in certain cases it may even exceed the latter figure. Thompson gives the case of a certain Siemens compound machine in which p would be over three. This, however, must have had a very insufficient amount of iron in the magnets or the armature core, or both. We fortunately do not have to deal with dynamos of such bad design very frequently. Provided we have known enough about the iron to be used in a given machine to design the shunt winding intelligently, we shall also know enough to design the compound winding. If we have at hand the characteristic curve of a similar shunt machine p can be determined very easily from it. I give herewith the data for the Manchester machine described by Dr. Hopkinson. I have simply taken the apparent permeability from his characteristic curve.

When magnetising force equals		$\frac{\text{induction}}{\text{magnetising force.}}$	equals	
When magnetising force equals	1,000	$\frac{\text{induction}}{\text{magnetising force.}}$	equals	470
,, ,, ,,	2,000	,,	,,	465
,, ,, ,,	3,000	,,	,,	460
,, ,, ,,	4,000	,,	,,	460
,, ,, ,,	5,000	,,	,,	460
,, ,, ,,	6,000	,,	,,	451
,, ,, ,,	7,000	,,	,,	443
,, ,, ,,	8,000	,,	,,	425
,, ,, ,,	9,000	,,	,,	400
,, ,, ,,	10,000	,,	,,	377
,, ,, ,,	11,000	,,	,,	353
,, ,, ,,	12,000	,,	,,	333

If the permeabilty curve of the iron is known even approximately we can obtain p from it quite readily. In Fig. 1, let $a\,b$ be the permeability curve. The permeability at no load corresponds to the point d, that at full load to the point f. Now lay off the ordinate $d\,e$ so that the ratio between $d\,e$ and $c\,d$ equals the ratio between the iron resistance and the air resistance of the proposed machine, then lay off from the point f the ordinate $f\,g$, equal to $d\,e$, and draw $g\,h$. Then the ratio of the lengths, $h\,c$ and $e\,c$, corresponds to the quantity p required. Fig. 2, drawn from Hopkinson's figures, gives numerically the change in permeability for cast iron. The figures relating to the Manchester machine were, of course, for wrought-iron cores and cast-iron poles. It is thus evident that a rather close approximation to the value of p can be made if we know anything about the iron that we are going to use. Now, as we shall see later, and as is, indeed, evident at the start, a and b are of about the same order of magnitude. I do not think that b will ever be negligible in a practical machine unless a is also negligible, and there is, therefore, little need for compounding. When the magnets are anyway near saturation b will be much larger than a, but both a and b combined will not give the proper number of series turns for constant potential unless the armature is run with no load, and therefore produces no demagnetising effect. The approximate demagnetising effect of the armature has been investigated by Hopkinson and is as follows:

$$4\,n\,C\frac{m}{2} \times \frac{2l}{\pi} = 4\,l\,m\,C.$$

In other words, it is due to the convolutions included in twice the angle of lead. For constant potential we must add then c turns in series equal

$$v\,m\frac{l}{\pi}.$$

It is evident at once that a change in lead will affect the compounding; an increased load will cause the machine to under-compound; a decreased load to over-compound. As, however, the amount of distortion in the field depends largely on the shape of the extremities of the pole-pieces, the above uncertain factor in compounding can often be gotten rid of by a little care in designing the poles.

It is obvious that the term c is to include the coefficient of leakage. Uniting now, the three terms, a, b and c, we have finally, as the completed formula for compound winding, the following:

$$n = p\frac{N\,r}{R} + \frac{\frac{N\,E}{R}(p-1)}{C\,x} + v\,m\frac{l}{\pi}$$

It now may be interesting to see how well this formula applies to practical machines. I regret to say that I have been unable to get full details of any machine which gave exact compounding, but I have obtained an assortment sufficiently large to show in a general way the applications of the formula.

Machine No. 1, 110 volts, 8 amperes, over-compounded 2 volts. For this small machine take p equal to 1·2. Applying the formula, a equal 14, b equals 44, c equals 15; total series turns by formula, 73; actual number, 90.

Machine No. 2, 110 volts, 3 amperes, over-compounded 3 to 5 volts. a equals 2, b equals 7, c equals 7; total series turns by formula, 16; actual number, 28.

Machine No. 3, 500 volts, 20 amperes. p equal to 1·1, a equals 3, b equals 15, c equals 14; total turns by formula, 33; actual number, 60. Machine over-compounded 3 to 5 volts.

Machine No. 4, 110 volts, 200 amperes, over-compounded 5 volts. p equals 1·05; lead rather large. a equals 2, b equals 2, c equals 5; total turns required, 9; actual number, 12.

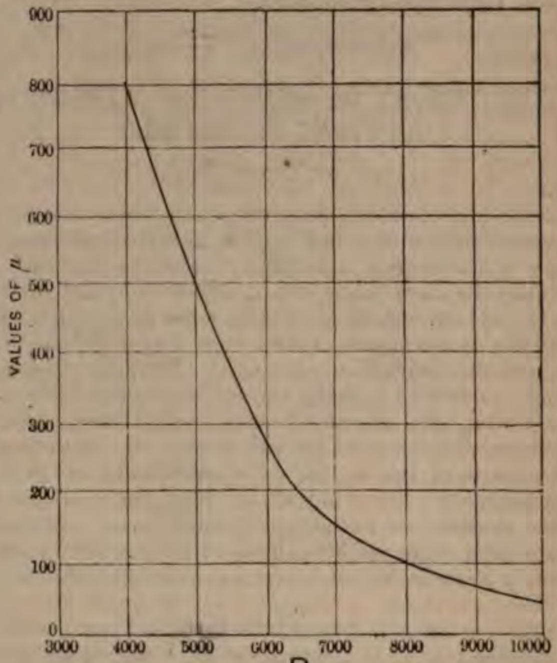


Fig. 2.

Machine No. 5, 500 volts, 60 amperes. p equals 1·05, over-compounded about 7 per cent. a equals 3, b equals 5, c equals 4; total, 12; actual number, 32.

Machine No. 6, 500 volts, 90 amperes. p equals 1·05; a equals 3, b equals 4, c equals 4; total turns should be 11; actual number, 19. Machine over-compounded like the former.

Machine No. 7, 500 volts, 150 amperes. p equals 1·05; over-compounded 7 per cent. a equals 3, b equals 3, c equals 3; total 9; actual number of turns, 28.

Machine No. 8, 100 volts, 30 amperes. p equals 1·1, a equals 13, b equals 46, c equals 25; total 84; actual turns, 56. Machine over-compounded about 2 volts, and the shunt winding did not bring the potential up to the 100 volts intended

These are merely rough figures, obtained without the use of even the permeability curve of the iron—simply by estimation from permeability curves at hand. It will be seen, however, that all the over-compounded machines got from the formula too few series turns, while the under-compounded machines gave too many. I think that the discrepancy is of about the right order of magnitude, although we cannot verify it accurately without the curve of the iron.

It remains to consider some few further points regarding compounding. If the winding is designed to give the potential at practically no load and at full load, it necessarily follows that at some point between the potential will rise; for, while the magnetising force changes along a line, the magnetic resistance changes along the corresponding curve between the same points.

An approximate idea of the amount of irregularity in potential may be gained from Fig. 1. Connect in this diagram *d* and *f* by a straight line. From its middle point drop an ordinate upon the axis. The length intercepted between the straight line and the permeability curve then gives the error in compounding by comparison with the total change of magnetic resistance.

It should be noted that the formula I have given determines the compound winding for a given assumed potential produced by the shunt coil alone; therefore, if the machine is to be run at a slightly different speed from that at first intended to produce this given voltage, the compounding is still correct, for it pertains to the voltage rather than to the speed. If the speed of a correctly compounded machine be raised and the current in the shunt kept constant, it will tend to over-compound. If the current in the shunt is allowed to increase, the change in resistance will decrease the relative power of the series coils, and the machine will under-compound.

It now only remains to glance at some of the formulæ heretofore given. That of Thompson I have already incidentally discussed. That of Frölich (perhaps the best we have had) should receive mention here. Frölich takes account of the change in the permeability by introducing a quantity *f*. Like Thompson, his formulæ involve two points of saturation. It should be said here that there is no special black magic about the half saturation point of a dynamo, any more than about the $\frac{3}{7}$ths or the $\frac{7}{13}$ths saturation point. In very many cases it happens to be about the point at which the machine is used. Kapp, in his well-known and excellent book, takes account of the change in permeability with a fair degree of approximation, by the use of his tangent function. All these attempts at the proper theory of compounding depend, like the one which I have just presented, on forming some sort of an estimate on the change in magnetic resistance of a dynamo, due to adding a certain amount of induction. Without some approximate method of finding this quantity, the problem is indeterminate, and the special thing which I have endeavoured to show is that from the data already at hand about iron we can form a sufficiently close estimate of the value of the coefficient *p* without either knowing the characteristic of the machine or indulging in endless approximations. I hope that some practical designer will look into the values that *p* takes in his machines, and I believe that it can be readily enough obtained to permit of quite accurate compounding by the use of the formula I have given. The introduction of the terms *b* and *c* I regard as important. Their existence has been well known, but I do not think they have received the attention that I have endeavoured to show they deserve.

ELECTRICAL ACCESSORIES.

While the details of dynamos and of underground mains are being perfected and brought up to date, makers of the interior fittings and accessories are not behindhand. A considerable number of very handy, ingenious, and handsome fittings for inside housework on electric installations have just been brought out by the Electrical Accessories Company, and illustrations of some of the most interesting of these are given herewith.

Several neat and inexpensive brackets are fitted with a recently patented universal globe carrier. One of these fittings is shown in Fig. 1, and they are made with several other patterns of bracket with glass shade or globe as Fig. 2, or also for pendants, as in Fig. 3. The fixing and removal of shades and globes for cleaning is greatly facilitated by the use of this carrier, and it is constructed to add to rather than detract from the appearance of the fitting. Various ornamental designs are made, and they are arranged to suit the fittings and lampholders most generally used. The illustrations show them as adapted both for globes and shades. In these patterns they screw on to the lampholder instead of the ring carrier; in other forms the lampholder itself screws upon a nozzle inside the carrier. The small carrier, Fig. 2, is for shades with small openings, $1\frac{1}{8}$in. to $1\frac{1}{4}$in. diameter; the larger size, Fig. 2, is for globes or pines of $2\frac{3}{4}$in. to 3in. opening. Similar sizes with claws reversed are made, suitable for flanged globes, It is pointed out, however, that one of the claims

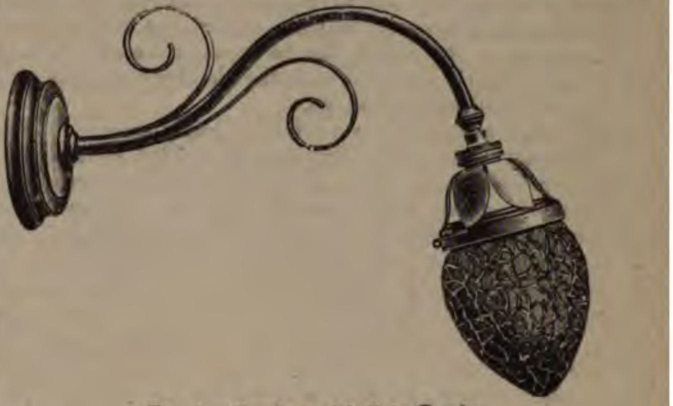


Fig. 1.—Bracket with Grip Carrier.

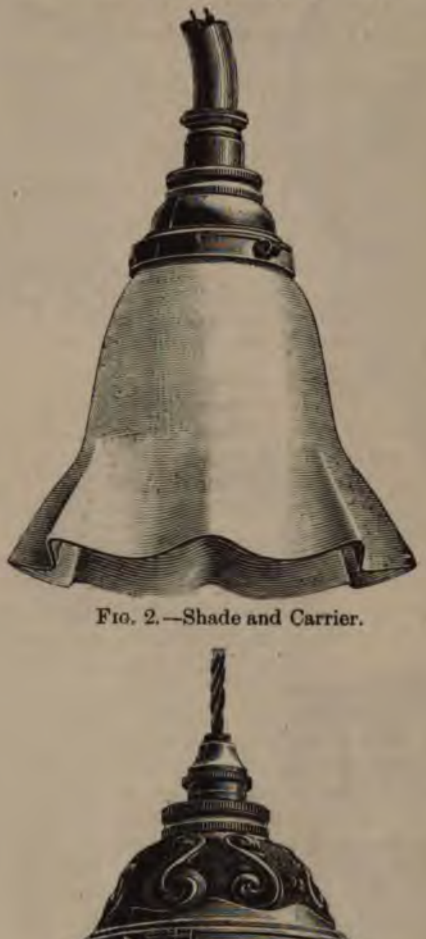


Fig. 2.—Shade and Carrier.

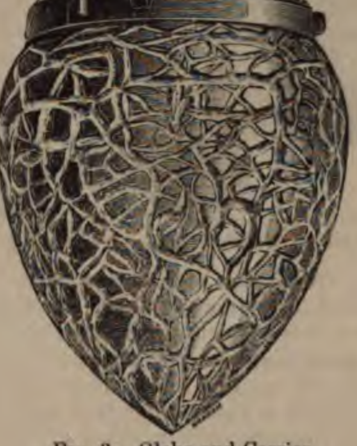


Fig. 3.—Globe and Carrier.

in favour of this carrier is that the flange on the glass is no longer necessary, and thus the cost of the globe itself is reduced, while the appearance is improved.

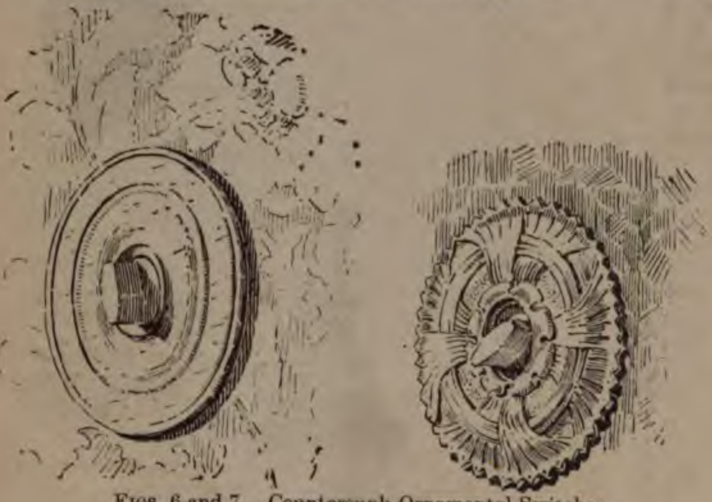
A considerable number of these carriers is now in use, and, as bearing upon the saving in labour for attendance and cleaning, it is stated that in practice the removal and replacement of the shades can be accomplished in one-fifth the time formerly required with the old screw carriers, and with less likelihood of leakage.

The inner action of this carrier is clearly shown in Fig. 4. The flat brass triple eccentric is guided centrally by three pins working in slots; the three claws are carried by slides working over the eccentric ring, the cam action of which causes the claws to advance or recede together.

approval of the fire insurance authorities. It is a switch which deserves and will doubtless receive a large success.

Some particular attention has been given to what are known as countersunk switches, those let flush into the wall with the thumb-piece only protruding. Specimens of these are shown in Figs. 6 and 7. In many, especially high-class installations, this style of switch is preferred, as better harmonising with the surrounding decoration. In the countersunk switch the working part is sunk in a box suitably constructed to prevent the penetration of moisture, while the cover is of chased brass of a variety of ornamental patterns, or may be bronzed or plated or made of wood as best may suit the surroundings or the taste of the owner.

The main spring contact switches illustrated are of a new pattern on Drake and Gorham's patent, an improvement on the well-known "ring contact" switches patented by the same firm some years ago. The advantages and simplicity, as well as the solidity of the construction, are apparent from the illustrations, Fig. 8 and 9. It will be seen that the circuit is completed by U-shaped strip from one terminal to the other. This is a special feature of the design, and its advantages include lower cost of construction, less space required, and the avoidance of any possibility of heating. The tension at the contacts is regulated by the distance pins between the arms. A flat steel spring is fitted to the base to keep the bar in its extreme


FIGS. 6 and 7.—Countersunk Ornamental Switches.

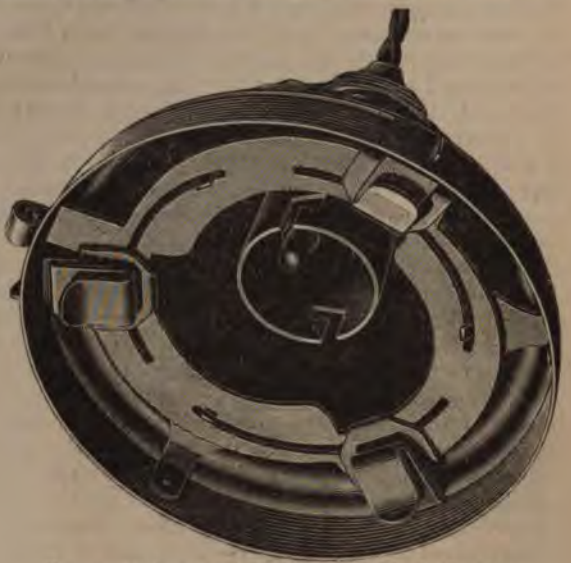


FIG 4.—"Accessories" Universal Shade Carrier.

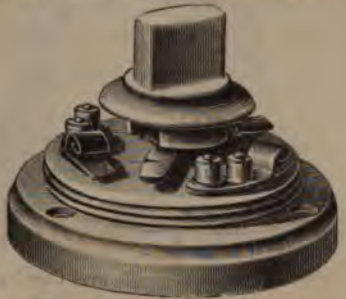


FIG. 5.—Porcelain Switch.

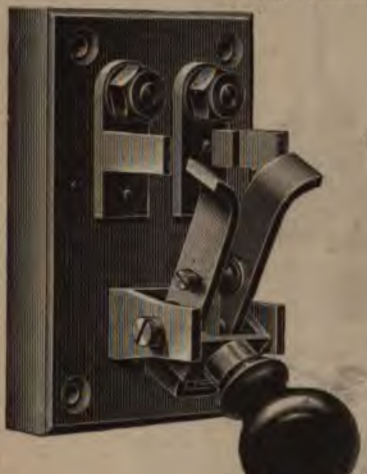
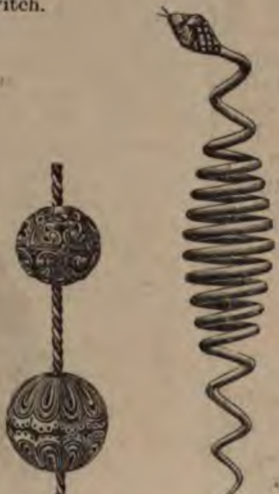


FIG. 8.—Spring Contact Switch.


FIGS. 15 and 16.—Cord Ornaments.

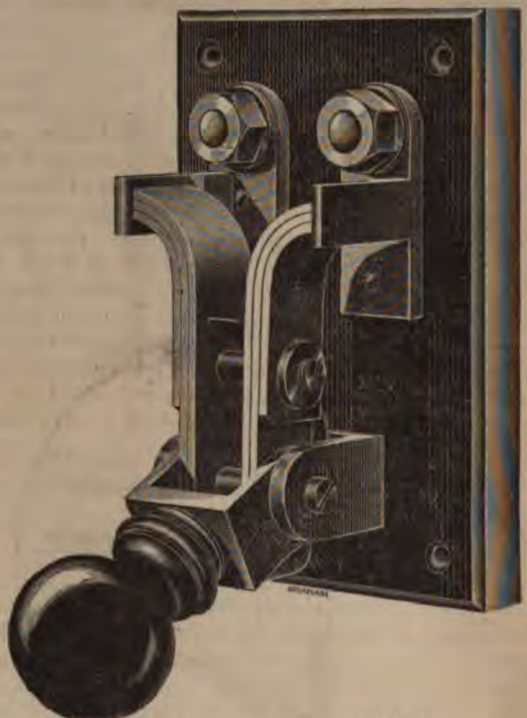


FIG. 9.—Main Spring Contact Switch.

In switches, a very neat and simple pattern, Fig. 5, has been brought out, combining in itself those good qualities which are absolutely requisite for a successful room switch. They have a porcelain base, and are made with an instantaneous break (under the well known Holmes's master patent); the circuit is from contact to contact across a solid bridge piece and not through working points. There is a double break of considerable distance, and space for a long fuse, while all the parts are most simple in construction. The question of easy fixing and other considerations from the contractor's point of view have been given special attention, and the construction has met with the full "off" position when the circuit is open. The switch may accordingly be fixed horizontally or with the handle at the top of such positions are more convenient.

A set of these switches, with suitable fuses fitted on a slate base, and provided with glass doors, Fig. 10, form a very useful main distributing switch-box.

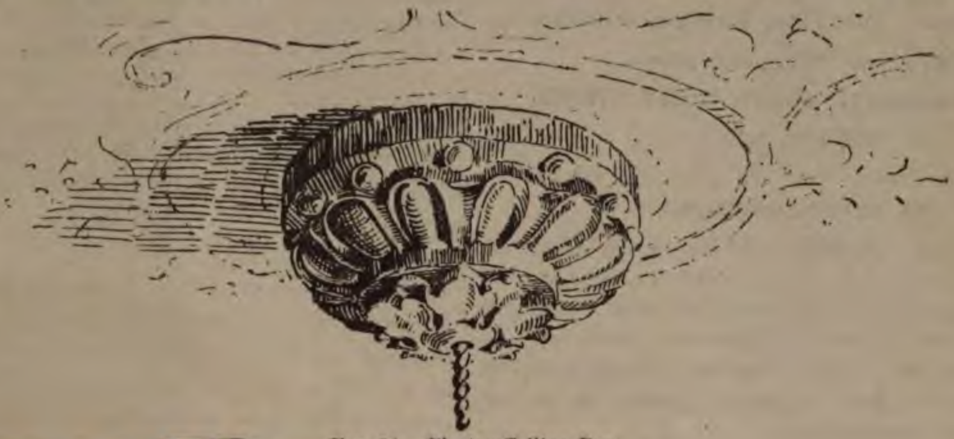


Fig. 14.—Plaster Ceiling Rose.

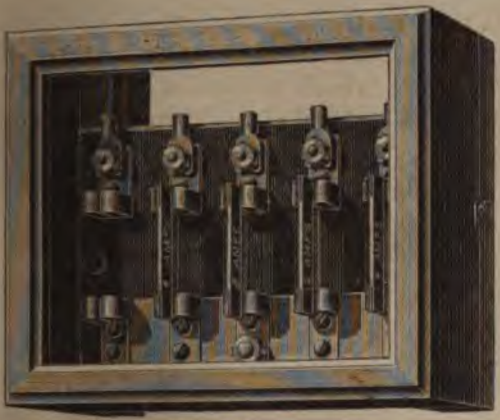


Fig. 11.—Branchway Fuse-box.

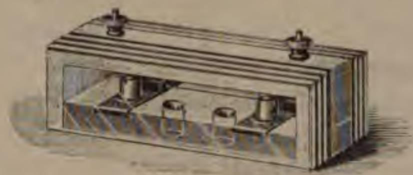


Fig. 12.—Casing Pattern Glass Fuse.

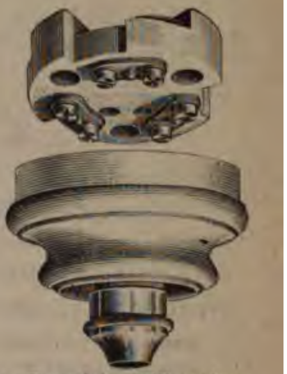


Fig. 13.—Porcelain Ceiling Rose with Cord Grip.

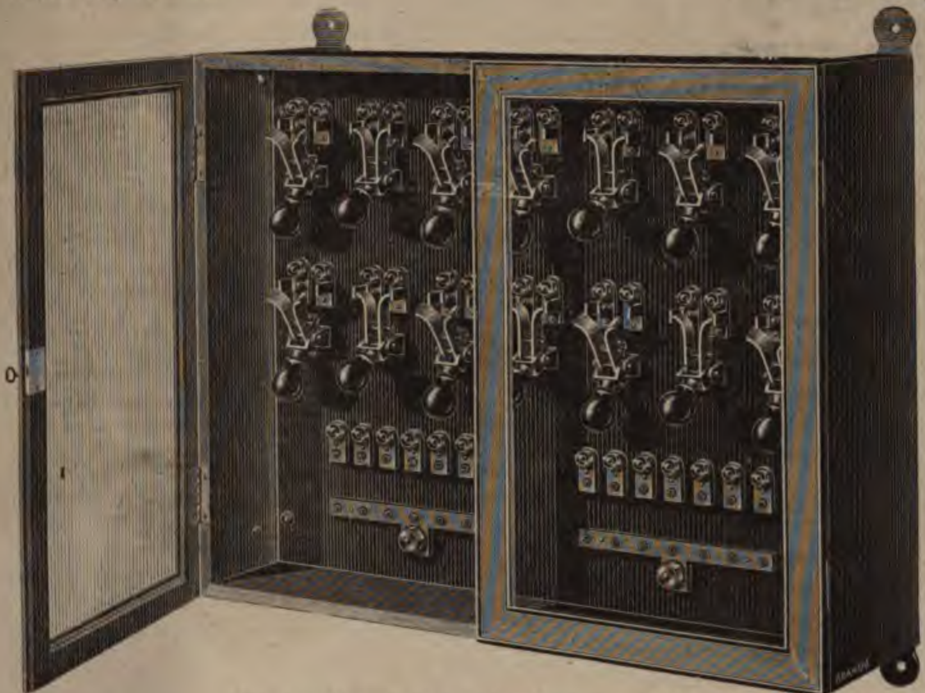


Fig. 10.—Distributing Spring Contact Switchboard.

A very useful form of fuse-box, with branchway fuses, for distribution on the various floors of a building from one source is shown in Fig. 11. We have already mentioned this type of fuse-box in connection with the installation at Madame Tussaud's, where they were first employed, and the form as now manufactured in box with glass cover embodies a highly-desirable method of wiring. The illustration explains itself—the "bridge" type of fuse, with the amount of current carried plainly marked thereon, can be readily slipped into place by an ordinary attendant, without the necessity for unscrewing and without fear of shocks or derangement of the other circuits. A neat little fuse case for single fuses, with glass sides and a cover in porcelain to imitate the ordinary casing, is shown in Fig. 12. The same type of "bridge" fuse, carrying up to five amperes, is used in this.

Amongst the other little "accessories" of which the Electrical Accessories Company make a speciality are wall sockets and ceiling roses. A new type of the ceiling rose is shown in Fig. 13, which illustrates a simple and efficient method of obtaining an easy fixture for the cover. The ceiling roses are fitted with a cord grip to bind the flexible cord, so as to take the pendant weight from off the terminals. They are made with either porcelain or wood covers. Fig. 14 shows an artistic adaptation to a plaster ceiling rose for a moulded ceiling of a drawing-room. Figs. 15 and 16 illustrate some little ornaments to attach lower down on the pendant cords.

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1891.

The year 1890 has not been productive of any great discovery in connection with dynamo-electric machines, or of any marked change in the method of applying previously known principles; but it has, nevertheless, been a year in which steady though slow progress has been made. This progress has been mainly in two directions—viz., the construction of more efficient large output machines, and the improvement and simplification of details.

The current of public opinion which set in so strongly a year or two ago in favour of alternate currents and high-potential systems of distribution appears, for a time, to have run its course, and just at present direct currents and low-potential systems of distribution receive more general favourable consideration. This being so, we must look to direct-current machines for most of the improvements of the year. We find that most of the large makers appear to be assimilating their types more and more to a uniform pattern. The single horseshoe form of magnet and the cylinder Gramme shape of armature now seems most in favour.

The demand for machines for electric power stations has not fulfilled anticipations, though the City and South London Railway just opened will, it is hoped, prove the first of a number of similar undertakings.

The great attention which has been paid to details in the making of the dynamos has resulted in the production of some first-class articles—machines one can not only admire, but depend upon.

In brush-holders the improvement is very marked, the simplicity and ease of handling of new ones contrasts very favourably with the clumsy appendages so named a few years ago. Though the wire gauze brush is gradually being more used, it is not superseding the old-fashioned straight wire one as rapidly as its early advocates prophesied.

The number of large output machines which have been built during the year is without parallel in the history of the industry in this country, and much work has been done in devising methods of overcoming the special difficulties met with in constructing them.

We have not heard much of the Fritsche disc machine, from which, or from some improved adaptation, we were led to expect great things; perhaps this is what 1891 will bring us.

The most notable contributions to dynamo literature during the year have been the two papers read at the Institution of Electrical Engineers—viz., "The Theory of Armature Reactions in Dynamos and Motors" by Mr. Swinburne, and "Some Points in Dynamo and Motor Design" by Mr. Esson, for which he has been awarded the Institution premium for the year. These papers, read immediately following one another and discussed together, form with the discussion a most valuable addition to our knowledge of the reactions which go on in large dynamo machines. In his paper Mr. Swinburne gave the results of two or three years' work in designing large dynamos. As the output, and consequently the current flowing through the armature, increases, it follows that the armature becomes magnetised through a larger range than when only small currents are used. Hence the effects of cross magnetisation become more marked, and the difficulty of sparking at the brushes is much increased. He advocated the use of small subsidiary magnets excited by means of the main current, and placed so as to neutralise the effect of the magnetisation caused in the armature. These, however, up to the present have not come into general use. Mr. Esson dwelt upon the necessity in designing a dynamo of having a symmetrical field through the armature, so as to ensure good electrical and magnetic balance, and noticed some of the devices used by various makers to counteract the magnetic pull on the armature in machines which have a single magnetic circuit. Passing on to the question of the maximum safe output to be continually got from dynamos, he gave for ring armatures a formula which he had used for some years with good results, and then went on to treat of the subject of the rise of temperature which could safely be allowed to take place in a machine while working. During the discussion which followed considerable differences of opinion were shown to exist among designers on this point. Many condemned the Admiralty limits of 14deg. C. after six hours' continuous running as being too rigid; and advocated such high allowable temperatures as 30deg. and 35deg. C. above surrounding temperature, or not more than 70deg. or 75deg. C. altogether.

These are a few of the chief facts which another year's experience in dynamo work has brought to us. There are yet many improvements—mainly in small details—necessary, which will eventually make the dynamo as reliable to work as it is economical to use.

It cannot be expected that any great improvement can be made in the construction of dynamos, especially if, as Mr. Crompton claims, they are now constructed to give 96 per cent. commercial efficiency. This is almost perfection so far as the electrical conditions go, and the only question to be asked is, whether such perfect electrical machines are good mechanical machines. It seems certain, however, that the mechanical arrangement must be almost or quite as good as the electrical, otherwise the efficiency could not be so large. With a perfectly balanced machine, then, of so great efficiency little room is left for improvement one way or the other.

FUTURE PROSPECTS.—In our request for information about the past year's work, among other questions we asked for an expression of opinion as to the future prospects. Without exception, all who have replied have given a favourable opinion. Everyone seems to think that the amount of work must progress. Many consider that progression will be by leaps and bounds, the only limiting quantity being workmanship. Many hold that the bright prospect will largely increase the numbers occupied in the industry, and lead to competition of so keen a character that prices will be unduly lowered. No doubt this is a danger, but it is even now somewhat difficult to understand how some firms can take contracts at the prices of their tenders. This point becomes still more difficult to understand when we find middlemen competing successfully against makers. We have been led to believe that prices for dynamos are too low now, and yet the middleman, who has to buy everything of the makers, can and does take work that makers compete for. Of course the reply to this is obvious, that the cost of the dynamos in a large installation is but a fraction of the whole cost, and if makers charge more for the other part of the work than the middleman, the latter must get the whole work, despite the competitors being makers. If this is so, makers must look to their charges for the other parts of the installation work, and not look to the being makers of machines to give them the advantage.

LOCAL AUTHORITIES v. SUPPLY COMPANIES.—Other questions upon which we solicited information related to the position of local authorities as against supply companies. Opinions upon these questions differ, some being emphatically in favour of supply companies. Others are not so strong in their objections to local authorities, but we must confess to a real surprise that not one was entirely in favour of local authorities. The general view seems to be that even when a local authority takes action, it is more often with a view to procrastination, and not with any real intention of doing work. This is surprising in that some local authorities, at any rate, have taken action. Witness work done at Taunton, Bath, Bradford, the work to be done at Barnsley, Northampton, Bournemouth, Brighton, Dublin, etc. We cannot expect a large percentage to move in these early days, and it really seems that the percentage who mean work is quite as large as could possibly be expected. However, the local authorities evidently do not find much favour in the eyes of electrical engineers. The following extract perhaps gives the most favourable opinion so far as local authorities are concerned:

"There is a great deal to be said on both sides. The principal objection to local authorities doing business is they are apt to perpetrate jobs. Some loud-voiced councillor names his friend whom he knows can do the work well. The loud-voiced councillor's friends support him, as he will do the same for them on another occasion; the loud man's friend gets the contract and is duly grateful. On the other hand, though if work done by public bodies is generally very expensively done, it is in the majority of cases well done, and that is entirely to the advantage of the advance of electricity. If a corrupt councillor is able to make his constituents pay more than they need do, the engineers on whom devolve the actual seeing the work carried out are usually on their mettle, and will have it well done. Where private companies undertake the work there is too often a strong temptation to do it too cheaply in order to make dividends. Private companies are too ready to compete with gas, often at a ruinous price, and then try to pay a dividend by doing the work cheaply. Later on the light fails, and the era of progress is stayed for a time. Our very best card is good work, no matter by whom it is done. Bad work injures everyone."

POWER IN NEW ZEALAND.—Although, as has been stated, power distribution does not make that rapid progress which was hoped for, installations here and there are carried out with success. The number of such installations must increase, and especially will this be the case where water power is available. In our colonies there are many sites admirably adapted for the utilisation of such water power, and we are glad to see signs of appreciation of electric transmission. About a year ago, Mr. Postlethwaite, the agent for the Electrical Engineering Corporation, put up a power installation at the Temuka flax mills, and from the time the current was first switched on up to the present the entire plant has worked with the most perfect success, and without a single hitch of any kind whatever. The dynamo is a mile away from the motor. It is stated that a great saving has been effected in thus substituting electricity for steam. For some time the machinery has been running night and day, and the cost of attending to the dynamo and motor has amounted to just 6s. per week, this being the amount allowed to the man in charge of the mill to visit the dynamo-house twice in every 24 hours for the purpose of switching on or off. The attendance on a steam engine would cost more than this. But of course water power is not everywhere available.

Another departure in the transmission of power of a unique character has been in actuating Wolseley sheep-shearing machines by motors. This has been carried out on Mr. W. Postlethwaite's Raukapuka estate, where 10 of these machines were electrically worked, and it is calculated that the extra value of the clip of 13,000 sheep has nearly recouped in one season the whole cost of putting up the machines. At Raukapuka a turbine drives a Statter dynamo. An overhead wire conducts the current to the motor which drives the shafting in the woolshed. Special arrangements are made to keep the speed of the shafting constant, though the work being done continually varies. The house at Raukapuka is lighted by electricity, and this agent is used in various ways.

GENERAL ELECTRIC POWER AND TRACTION COMPANY.—About the middle of this year the business of Messrs. Immisch and Co. was amalgamated with that of the Electric Traction Company; the two firms now trade under the title of the General Electric Power and Traction Company, Limited. The new company have primarily for their main object electric traction and general power work; but they in no wise confine themselves to these branches, and have, during the past year, accomplished a considerable amount of lighting and general work. Their business may be roughly divided into four branches—viz., 1, mining work; 2, tramcar work; 3, electric launch work; 4, general work. Work in the mining department has been exceptionally brisk, and installations have been erected in England, Wales, Scotland, the Continent, Asia, Africa, and Australia. Without going into details it may be mentioned that almost the whole range of mining work has been successfully accomplished by the Immisch plants; winding, hauling, pumping, fan-driving, rock-drilling, etc., having been carried out in different pits, and in nearly all cases the plants have been arranged on the compound parallel system so as to be adapted for both lighting and power. The aggregate horse-power supplied during 1890 in dynamos and motors for this purpose is very nearly 1,000 h.p. In tramcar work, although no new lines have been laid down in the past year by the company, they have made considerable progress in the general details of accumulator work, and have successfully run their cars on the North Metropolitan Tramway Company's lines at Barking during the whole of the year. The total mileage for the year is approximately 80,000 car miles. According to schedule time the possible mileage was approximately 1 per cent. more than that actually run. The experience thus gained has enabled the directors to undertake the maintenance of electrically-equipped accumulator car lines at rates which will compare favourably with horses. The company is prepared to treat with tramway companies on these conditions, and have now in course of preparation estimates for several important lines. With regard to electric launch work, during the past summer the company had launches both on the Thames and on the Union Canal at Edinburgh, during the late exhibition. The number of passengers carried at Edinburgh was about 100,000, and the result commercially was thoroughly satisfactory. On the Thames some 12 launches were kept for hire, and although the season was a bad one, yet they were patronised by the public to a large extent. Many important improvements in motors, switches, and propellers have been introduced by the company, and in the coming season it is expected that a very considerable increase will be made in the number of boats plying for hire, and consequently in the financial returns of this department. The general work of the company during 1890 was far in excess of that of the previous year, and shows a large increase in the demand for motors suitable for central stations, and motors for special machine tools have been in fair demand. A large number of dynamos for electric lighting have also been supplied by the company, and several important installations have been carried out. Amongst others may be mentioned Tatton Hall, Knutsford, the residence of Lord Egerton of Tatton. The prospect for 1891 is decidedly good, and the company starts the New Year with a large number of contracts in hand. Several important mining plants are now in course of erection, and others are in negotiation. Electric traction is undoubtedly coming well forward, and the next 12 months will see several schemes brought to a successful issue.

HENLEY'S TELEGRAPH WORKS.—The business of this company for the past year has been very good, and considerably greater than 1889. In the early summer they successfully laid the cable between Halifax (U.S.) and the Bermudas (850 nautical miles), and have since constructed 1,021 nautical miles of cable for the West Indies and South America, the laying of which has just been satisfactorily completed. The company has altogether had a very successful year in its submarine cable department, other cables made in addition to those referred to above being the cable for connecting the Island of Anticosti, in the Gulf of St. Lawrence, with the mainland, for the Canadian Government; a new cable between Nyborg and Korsor, in the Baltic, and various small cables for home and abroad. In the manufacture of vulcanised indiarubber electric light mains and cables, and wires for house wiring, the company has been exceedingly busy. Most of the London and provincial supply companies are buyers of Henley's vulcanised indiarubber mains. The company has just opened a stockroom to meet the requirements of their customers at 27, Martin's-lane, Cannon-street, for immediate delivery of any standard sizes of wires and cables.

TELEGRAPH MANUFACTURING COMPANY. — The works of this company have been extremely busy during the past 12 months and all departments have been fully employed. The guttapercha wire made by this company has been in such demand, that although the plant has been doubled, the supply has scarcely been able to keep pace with orders. It has been found necessary to erect new buildings for the battery and insulator departments in order to cope with the work, and also to take large premises in Liverpool for the instrument department. All these will be in working order in a few weeks, and then the whole extensive Helsby Works will be solely devoted to the manufacture of electric light, telephone, and telegraph wires and cables, and very shortly the company will be in a position to more than double their already large output.

SYDNEY F. WALKER AND CO. cannot show a very large record of new work during the past year, not so large as they would like, owing to the keen competition which has prevailed. There has been plenty of work, but plenty of people to do it. During the summer this firm laid down a 400-light plant for a large coal and iron firm in Lancashire. As rather a new departure was made in this case the details may be interesting. The installation consists of two complete and independent plants, each capable of furnishing 200 lamps or their equivalent. Separate engines and dynamos are used, not connected in any way; and the whole is so arranged by means of specially designed switches, on Mr. Walker's bent spring principle, that either engine and dynamo can be switched on to any part of the work at will. When the full output of the plant is taken up, one dynamo and engine will work the surface lights and the other the underground lights, but at present one dynamo runs all the lights that are required for 24 or 48 hours, then the other is run, and so on. In Mr. Walker's opinion this is the plan upon which installations should be put down, as it gives so many more chances against a breakdown. Later in the year they put in another installation for the same firm, consisting of a 100-light plant. In both cases incandescent lamps of 16 c.p., 50 c.p., 100 and 200 c.p. are used, showing the wonderful adaptability of the incandescent system with the compound dynamo. This firm has also fitted up another colliery in Lancashire with a 100-light plant. They have had their usual mining work as in past years, and in addition have done a good deal of wiring and fitting up in connection with the Newcastle supply companies, and in other towns. An important piece of work that was undertaken and successfully carried through was the construction of a 3,000-ampere switch for use in connection with some experiments that were being made for the production of aluminium by the aid of the electric current. The slate base alone weighed over a hundredweight, and the details involved were more like those met with in engine-building than in switch-making. During the year they have considerably modified the construction of their dynamos in order to keep pace with the advancing knowledge on the part of users. To meet immediate requirements, they have made a dynamo on the old lines, but with a bobbin very much elongated, the machine itself being the same length as before, and the bearings being quite outside the frame of the machine. So far, this dynamo has run remarkably well. Mr. Walker's views up till recently were that it was unwise to depart from the old type first introduced by Gramme, except to add iron, and thereby increase the efficiency; as it was of more importance for a dynamo to be very simple than to save a few tons of coal in the year. Recently, however, he has found so large an increase in the knowledge of the subject among users, that his firm have been induced to join in the general procession of dynamo makers; and he has designed a single horseshoe dynamo—something on Mr. Kapp's lines—in which he claims to have included all modern improvements that are suitable for his work, and that are open. It is named "The Patriarch."

WEEMS'S SYSTEM.—In America and elsewhere the pithy descriptions that have been given of the Weems railway system, led us to enquire what the prospects of this system are. Mr. Weems, in reply to our enquiries, says: "We have every indication of making a most splendid success in our rapid transit in this particular line, and propose at no very distant day to convey passengers and mails at a speed of 120 miles per hour with perfect safety and convenience."

"It does not require a very vivid imagination to appreciate what a revolution will then be made in railroad traffic throughout the entire world."

If Mr. Weems's supposition is correct we shall hail with pleasure a practical exemplification of his scheme.

WOODHOUSE AND RAWSON.—The year ending 31st December, 1890, shows very rapid strides and developments in the well-known undertaking of Messrs. Woodhouse and Rawson United, Limited, one of the most enterprising and progressive of the electrical firms. The company in the beginning of the year removed their head offices from 11, Queen Victoria-street, to very extensive premises having frontages to 30, Cannon-street, and 88, Queen Victoria-street respectively, but notwithstanding the size of the new premises to meet the requirements of their increasing business, the company have been obliged to take the whole of an adjoining block of buildings forming the apex of the triangle facing Mansion House Station, leading to Cannon-street on the right hand, and Queen Victoria-street on the left. The new showrooms will be at 34, Cannon-street, and the secretary's office at 88, Queen Victoria-street. Among the leading developments of the business may be mentioned the purchase and working of the large engineering works at Kidsgrove, near Stoke-on-Trent, lately carried on by Messrs. Renshaw, King, and Co., at which place the company are able to cope with any demands which may be made for heavy mechanical engineering work such as boilers, engines, central station dynamos, cranes, tanks, girders, hydraulic presses, etc. Then again the important and growing business of electrical and steam launch building has been added to the other resources of the company by the purchase of the business of Mr. W. S. Sargeant, of Chiswick. Important branch offices have been opened in distant parts of the world—viz., Sydney, Melbourne, and Johannesburg; while other depots such as Alexandria, Amsterdam, Barcelona, Bath, Bombay, Buenos Ayres, Cadiz, Cork, Dunedin, Hamburg, and Yokohama have been opened.

At their Cadby Hall Works the company have erected a huge new building to accommodate their largely-increasing business in the manufacture of lamps, switches, fuses, switchboards, instruments of all descriptions, etc. To provide the necessary power they are adding a large pair of compound engines, and the necessary boilers, and the whole of the shafting and tools will be run by electric motors. They have also added a new department for making an accumulator which it is thought will cause the greatest stir yet known in the central station accumulator world, and in addition they have largely increased their electroplating facilities, so as to extend their outdoor work for the trade under the direction of Mr. William Elmore. The company has also during the past year most successfully introduced the following important enterprise—*i.e.*, the International Okonite Company, whose business has very largely increased since its formation, more than bearing out the statements in the prospectus, and whose specialities have been of great assistance to those engaged in furthering the interests of electrical work, more especially in America, where the new works of the company have more orders than they can supply. The company has also aided in the successful sale of the French, German, and Austrian Elmore patents, and the commencement of working under the same. In the important branch of the company's business known as the contract department, in which installation work is carried out, very marked and satisfactory progress has been made, and it is doubtless due to the fact that the principle has been most rigidly adhered to of not accepting or carrying out any cheap or inferior work. The very best materials that can possibly be bought, together with highly-paid skilled labour, are only used, and the company has the satisfaction of finding that a very large proportion of the work secured by them comes through the recommendation of clients for whom they have already worked. In the Yorkshire district alone 42 installations have been carried out by the Bradford branch. Among the more important may be mentioned: London and Yorkshire Bank, York Municipal Buildings, the Bradford Club, Bradford Banking Company, the Borough Buildings, Bradford Borough Court, Public Art Gallery and Free Library. In the Lancashire district, among the larger installations carried out by the Manchester branch, may be mentioned a 700-light plant for Messrs. Dobson and Barlow, engineers, of Bolton, a second order having been received recently. The central station lighting work at Barcelona has been planned out by the company's engineers, and in a short time the new system of incandescent lighting plant, with underground mains, supplied by the company will be in operation. Repeat orders for installation work have been received from the Marquis of Ripon, Savoy Mansions, Crosse and Blackwell, Clowes and Sons, W. H. Smith and Sons, Strand, the Salisbury Club, J. W. Benson and Co., and other well-known firms, while among the more important maintenance contracts may be mentioned those of Draper's Hall, Exeter Asylum, and Lord Brassey; whilst a part of the lighting work at the Edinburgh Exhibition has been carried out, and there is a very large quantity of work now in hand. In the supply department various articles of importance have been introduced to further electrical engineering, and the turnover has increased 100 per cent. in the last 12 months, whilst the new showrooms at 84, Queen Victoria-street will enable the company to place a larger and more varied assortment of the most approved patterns before intending buyers, so as to facilitate selection.

In the business of manufacturing, the company holds the contracts for the London and North-Western Railway Company, the Great Eastern Railway Company, and the Caledonian Railway, and have executed contracts for the Admiralty, the General Post Office, and the Midland Railway, whilst many articles have been manufactured, such as galvanometers, signal repeaters, contact-boxes, signal expansion tubes, firing keys, numerous electric bells of all sizes, relays, telephone and electric lighting switchboards, train-starting and saloon indicators, single-needle block instruments, lightning protectors, fusible and automatic cut-outs, lamps, tachometers, automatic oil filters, many thousands of switches of all sizes from five amperes upwards, large contracts for brass castings, automatic boxes, automatic advertising, coin-checking and other automatic machinery, lathes, drills, screw-making machinery, and other tools specially adapted for electrical work. Amongst other heavy engineering work carried out at Kidsgrove may be mentioned complete electrical and mechanical plant for a small central station at Palace-chambers, Westminster; complete mechanical and electrical plant for Woking central station; contract for supplying and laying 15 miles of mains for the Audley Local Board Water Works, together with compound engines, boilers, 100ft. deep well and pumps; gas works plant for Birkenhead Gas Committee; petroleum storage tanks about 70ft. in diameter, capable of holding 2,000 to 2,500 tons of oil, for the Mersey Dock and Harbour Board of Liverpool; seven locomotive steam cranes of from five to 25 tons capacity, together with many high-class engines and boilers, including steel boilers 32ft. in length, water softeners, etc. A considerable number of electric launches have been built at the company's yards at Chiswick, amongst them being the "Volt" (the fastest ever built for her size), and various launches from 28ft. to 31ft. long, having an average speed of about 8½ miles per hour. For the English Government a very important departure has been made in building an electric pinnace capable of carrying 40 soldiers—another pinnace of this class having been already built for a steam yacht. Four steam launches, from 30ft. to 52ft. in length, have been also built, the largest one being for the Mexican Government. As steel launch building requires special appliances, a special yard has been recently laid out for building steel launches of every description. The company, after writing £7,000 off patents account, paid a dividend for the year of 15 per cent., put £25,000 to reserve fund, and carried forward over £16,000.

WOODSIDE ELECTRIC WORKS.—During the past year this firm has been exceptionally busy; in fact, for some time during the autumn they had as much work as they could well undertake. The principal work has been the supply and erection of complete isolated installations of electric light in factories, yards, and steamships, and the increasing demand for the Woodside dynamos, arc and superincandescent lamps, and fittings generally, is very encouraging. The outlook for 1891 is hopeful. They start the year with a large number of orders already booked, and many installations which have been erected in factories with a view to larger installations, if successful, will doubtless result in a large amount of business.

Deptford Station.—The London Electric Company are busily engaged in putting in order their distributing stations at the Grosvenor, as well as the other sub-stations, but there does not appear to be any possibility of the lighting being resumed for another two or three weeks.

UNDERGROUND MAINS.—II.

THE CROMPTON SYSTEM.

(Continued from page 9.)

In laying out a system of mains the position of the generating station is taken as centrally as possible. The streets are laid out with mains in the simplest and most direct manner, and feeder points are then determined upon at various points upon the plan. In the streets where no feeders are required a culvert for three wires only is laid, but where one pair of feeders go alongside the mains, a culvert for five wires (the three wires and one pair of feeders) is necessary. Near the station where feeders in two directions are required, culverts for seven wires (three wires and two pairs of feeders) are laid, and so for other parts of the circuit. These three sizes are shown in the illustrations. The sizes inside are respectively 1ft. 3in., 1ft. 8in., and 2ft. wide.

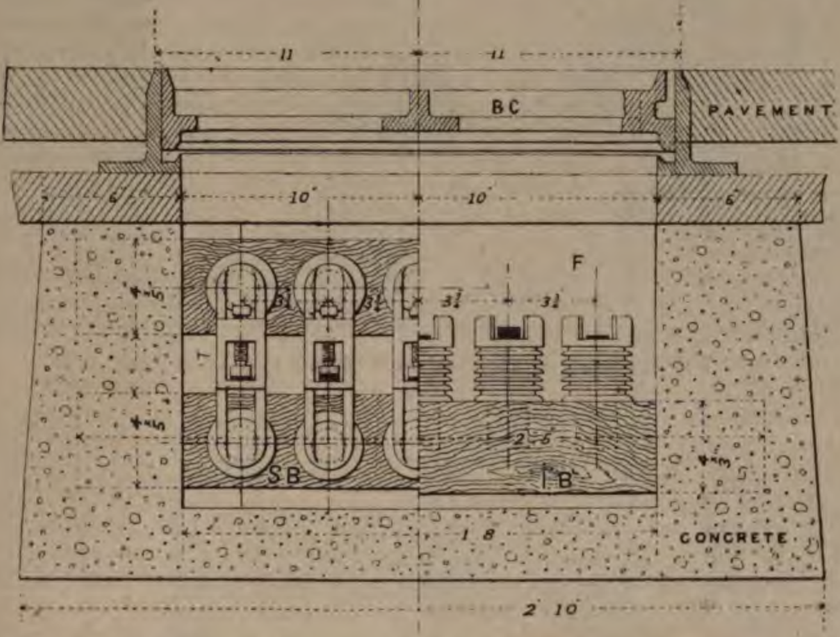

FIG. 4.—Section of Culvert—3-wire mains with one pair of feeders.

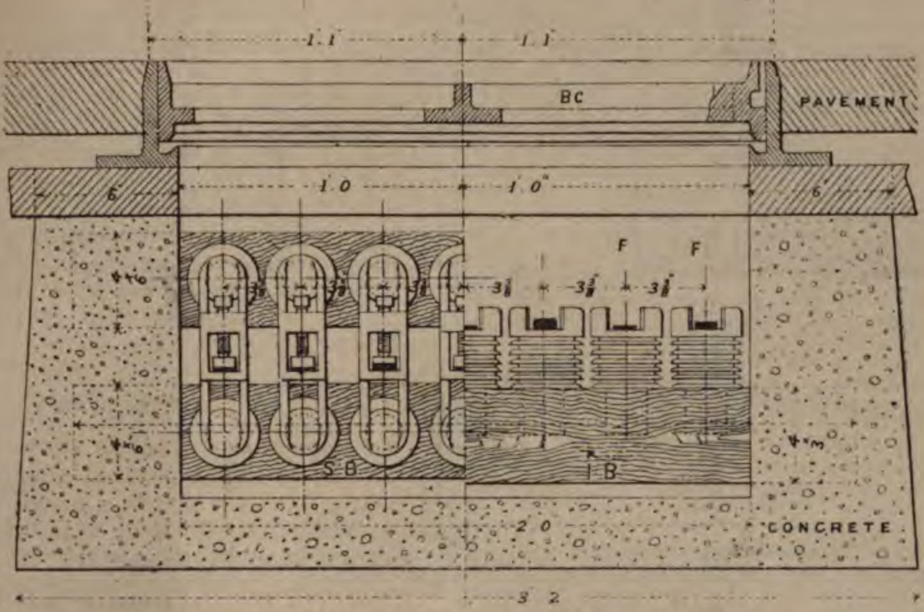

FIG. 5.—Section of Culvert—3-wire mains with two pairs of feeders.

The trenches for the culverts are made, wherever possible, under the pavement, and the usual type of boxes are made for this situation. Occasionally, however, it is necessary to lay the mains in the roadway for some length, or to cross the road from one side to the other, and the culverts and boxes are then made extremely strong to withstand the ordinary traffic or even the passage of a steam roller.

The size of trench for the ordinary main on the Crompton system is 2ft. 5in. wide, and for the largest culvert 3ft. 2in. wide by 1ft. 9½in. deep.

The first process, when actual laying is begun, is the digging of the trenches and the construction of the culverts. These are laid in concrete, of the required width of opening, with the walls biased outward at the base for strength; first the floor is laid in concrete, and then the walls of the culvert, which are kept up by rough boarding till firmly set.

The second part of the work is the construction of insulator boxes. At every alternate house along the road—roughly, at the distance of every 15 yards—arrangements for an insulator box are made. This box serves both for allowing inspection of the insulator and as a junction box for either of the houses. An oak baulk, 4in. by 3in., for supporting the insulators, is embedded in the concrete, each baulk having round holes drilled in its centre for the after reception of the insulator. These insulator baulks are marked with the letters I B on the figures.

Thick York flagstones are now placed along over the culverts, and the surface is filled in and rammed down and the pavement replaced. At the places for insulators a metal frame is bedded in the concrete. Each of these frames has a properly fitting lid or box cover, B C, and these box covers are previously filled in level with concrete, so as practically to form one continuation of the pavement itself.

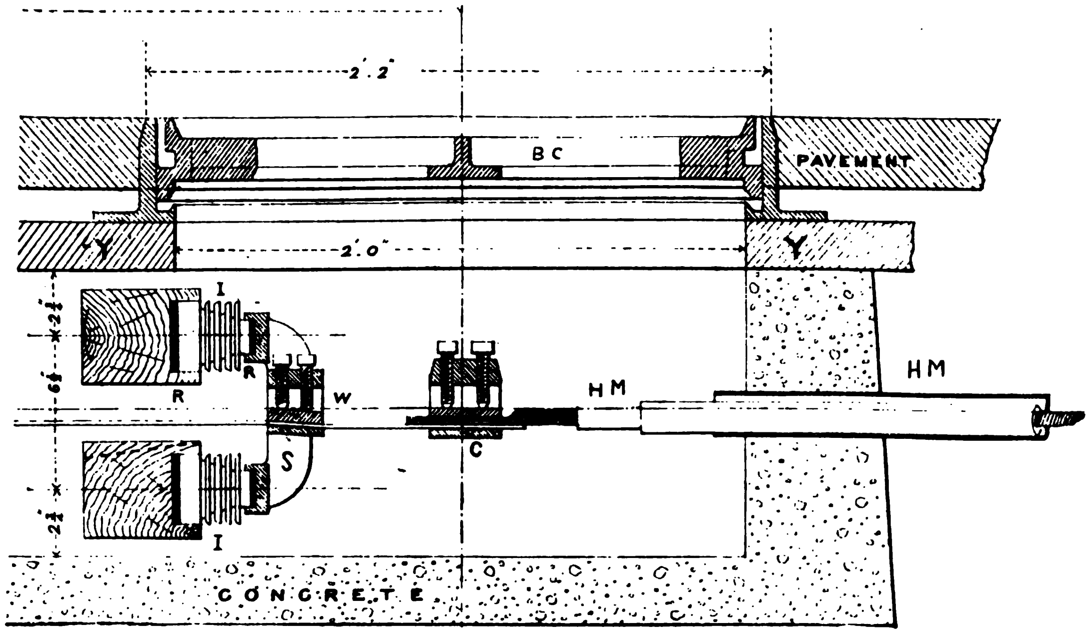

Fig. 6.—Straining Piece and Joint of Strip to Cable in Pipe.

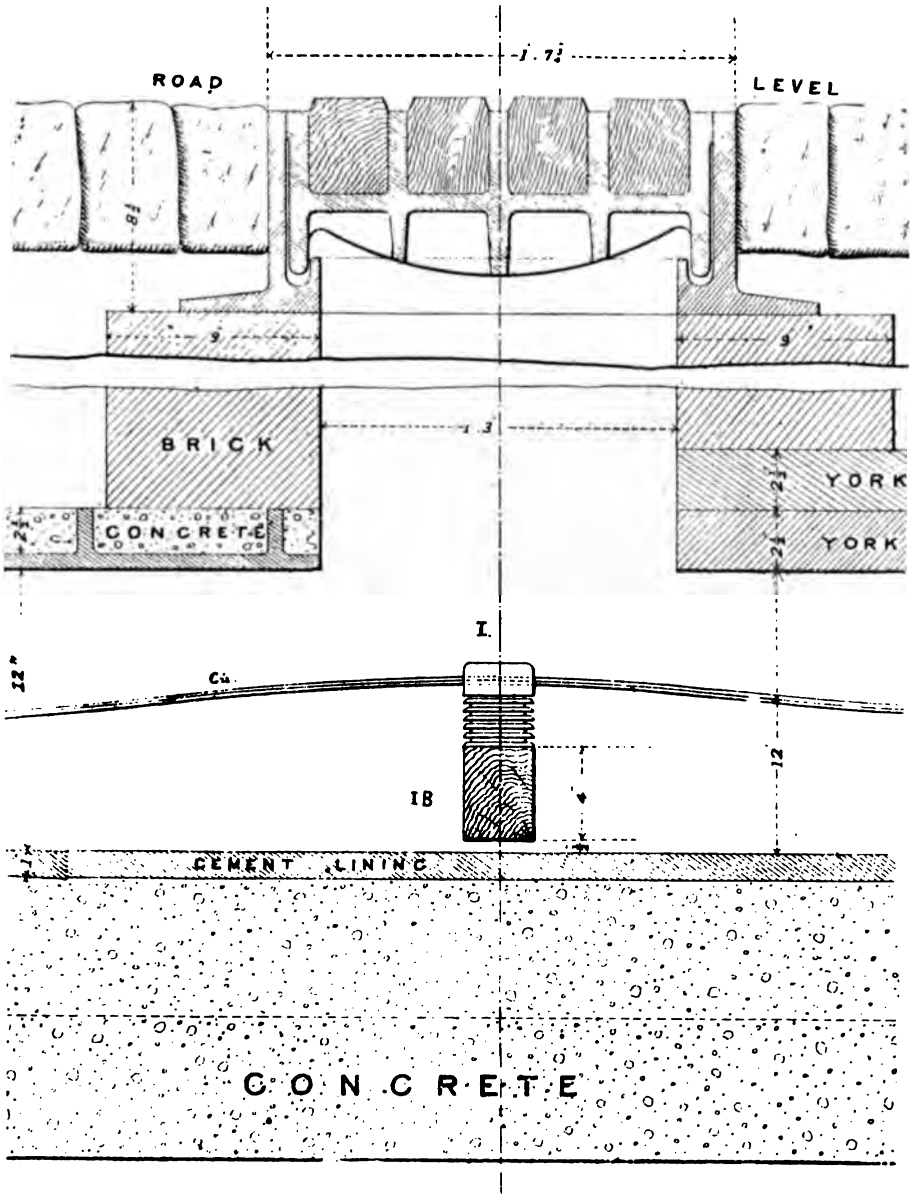

Fig. 7.—Insulating Box in Culvert under Roadway. Longitudinal Section, showing alternative systems with York stone or iron and concrete covering.

At certain distances along—from 20 yards up to 100 yards if the road is straight—provision is made for straining-boxes. Two baulks of oak are firmly bedded in the concrete one above the other, and form the fixed parts to take the strain of the copper strips. The size of the baulks is 4in. by 4in. for ordinary mains, 4in. by 5in. for mains with one pair of feeders, 4in. by 6in. for mains with two pair of feeders. These straining baulks are marked S B in the illustrations. After they are laid the spaces above are covered in with cast-metal boxes and covers of the same type as the others.

(To be continued.)

TRANSMISSION OF POWER BY MANILLA ROPES.*

This paper, by Mr. J. H. Gregg, which was read before the Western Society of Engineers, contrasts the English system of separate ropes for transmitting power from the prime mover to line shafts with the American system, in which one continuous rope is employed, independently of the number of grooves in the sheaves, with an automatic tension-carriage for taking up slack and giving tractional force, which is dependent on the weight applied to the pull-back. The sheaves for American rope gearing are of two kinds, drivers and idlers, or carrying sheaves, distinguished by the form of the grooves, which for drivers include the angle 45deg., and for idlers are semicircular in section.

Mr. Gregg quotes a safe formula for ordinary practice, constructed by E. D. Leavitt, jun., for the horse-power of driving ropes, as follows :

$$\text{H.P.} = \frac{G \times D \times R}{200} v.$$

G = circumference of rope.
D = diameter of sheaves in feet.
R = revolutions per minute.

The annexed table was calculated by means of the above formula :

Rope Transmission of Power.

Speed in feet per minute.	1000	1500	2000	2500	3000	3500	4000	4500	5000
Diameter of rope.	Horse-power.								
Inches.									
¾	1¾	2¾	3½	4½	5½	6½	7	8¼	9
1	3¼	4⅛	6½	8	10	11	13	15	16
1¼	5⅛	7½	10¼	13	15	18	20	23	26
1½	7½	11	15	18	22	26	30	34	37
1¾	10	15	20	25	30	35	40	45	50
2	13	19½	26	33	39	46	52	59	65

The margin of safety, according to this table, appears to be considerable. The Chicago Arc Light and Power Company run successfully 50 light dynamos with two ¾in. ropes, travelling at a speed of 3,516ft. per minute, and transmitting 50 h.p., or about four times as much as would be calculated from the table.

The average breaking strength of the manilla rope is about 10,000lb. per square inch of section.

INDUCTANCE AND ITS PROPOSED UNIT THE HENRY.†

BY A. E. KENNELLY.

(Concluded from page 11.)

Thus far we have only considered the centimetre or absolute unit, whose unfitness for practical use is evident, since the smallest inductance that is at present known to engineering amounts to several thousand, while the average values met with are counted in millions of centimetres. It would, of course, be possible to name suitable units from the metrical system of lengths, but it is the proposal of this institute to adopt the word "Henry" as the practical unit, in honour of the man who, beyond all doubt, was among the foremost to extend the knowledge thus far possessed of self and mutual inductance.

If the selection of the practical unit were entirely free and subservient only to practical requirements, so that its magnitude should express ordinary values in digits with fewest decimals on the one hand, or large numbers on the other, there seems most reason to believe that the thousandth of the earthquadrant or myriametre would be the most eligible.

Proposed name.	Length.	Number of centimetres.	Unit.
Henry.	Earth quadrant.	1,000,000,000	Practical unit.
		100,000,000	
		10,000,000	
Millihenry.	Myriametre.	1,000,000	
	Kilometre.	100,000	
	Hectometre.	10,000	
Microhenry.	Decametre.	1,000	
	Metre.	100	
	Decimetre.	10	
	Centimetre.	1	Absolute unit.

Of course large iron machines employing many turns of wire linked by dense magnetic fields would have inductances more appropriately expressed in earth quadrants, which might then be termed the kilohenry just as we now have the watt and kilowatt, but there is one restriction which makes such a selection undesirable, and that is the hitherto unbroken system of practical units itself. This practical system is a sub-scheme of the great international C.G.S. system, and especially planned for adaptability to practical requirements. It is derived from that parent system by the substitution for the unit of length, one thousand million centimetres in place of one centimetre, and for the unit of mass an impalpable entity definite only in thought, the one hundred millionth of a milligramme in place of the gramme. By this substitution in the C.G.S. electromagnetic units, we obtain the hitherto unbroken system of the volt, ohm, ampere, coulomb, joule, watt, and farad. Even these units are not always the most convenient, witness, for example, the microfarad in common use, whose prefix is maintained simply in deference to the harmony of the system, for the farad is a capacity that exists only in imagination ; the capacity of the earth itself being only about 700 microfarads, and of the sun—or, rather, a sphere having the apparent dimensions of the sun—being only about 76,000 microfarads. On the other hand, a proposition has lately been made to infringe the system by making the volt, the ampere and the watt, ten times their present values, on the ground of practical convenience. However, at the present time, it would surely be unadvisable to attempt the precedent of infringing a system that has hitherto been supported by time, custom, and international congress.

In this practical system, the unit of inductance must be 1,000 million centimetres. That is an earth quadrant or the distance from the pole to the equator, measured on the meridian of Paris. Strictly speaking, it is only the quadrant of the French standard earth, which is about one-tenth of 1 per cent. shorter than the acknowledged actual earth quadrant, according to the best determinations, but the fact of the latter being 10,001 kilometres instead of 10,000, is a matter of precision in definition only and in no way affects the practical unit.

As regards the history of the subject, it would appear that prior to 1887, measurements and deductions were confined to scientific works, and were expressed in absolute units—centimetres. In that year, however, a paper was read before the British Institution of Electrical Engineers by Messrs. Ayrton and Perry, who invented and developed a practical measuring instrument for the measurement of inductance, who, aided by Dr. Sumpner, made important contributions to the literature of the subject, and who proposed a name provisionally for the practical unit. That name was the secohm, a contraction of second-ohm, implying the fact that the product of the two was the length equal to the practical unit. They drew attention to the fact that since the Paris Congress of 1884 had fixed the standard legal ohm as the resistance of a column of mercury at zero centigrade, 106 centimetres long and one square millimetre in cross-section, whereas the true ohm was in all probability 106·3 centimetres, or one-quarter of 1 per cent. greater, the inductances measured in the manner they suggested from seconds and legal ohms, would be in terms not of the standard earth quadrant of 10,000 kilometres, but of legal earth quadrants 9,778 kilometres in length. The difference practically is not very great, but to avoid error or confusion in definition they advocated provisionally the term secohm in place of quadrant.

The Paris Congress of 1889 adopted the "quadrant" as the practical unit of inductance, defining it as 1,000 million centimetres.

The practical range of inductances is second only to that of resistances, and the latter we know from a few microhms up to thousands of megohms. The smallest inductances are those of Hertz resonators which descend to the order metres. Excluding these, however, the smallest are perhaps met with in measuring instruments intended to have negligibly small inductance, such as doubly wound resistance coils, Cardew voltmeters, and the like. These descend to the order of decametres, and can generally be expressed as such without prefixing decimal points. It is evident that the term microhenry would suitably apply to their designation. At the other end of the scale we find large induction machines linking dense fields with many turns of wire, and reaching inductances of hundreds or even thousands of henrys. Intermediate between these limits, there exists a large class of circuits having many turns but little iron, or clad in iron with few turns of wire, and these seem to be best expressed by the term millihenry, equivalent to the myriametre.

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* From "Abstract of Papers," published by the Institution of Civil Engineers.

† A paper read at the fifty-second meeting of the American Institute of Electrical Engineers.

With the object of setting forth the advantages to be derived from the use of this nomenclature, it may be permissible to adopt it provisionally in describing the measurements that follow. These measurements have been made on different types of apparatus at different times and by different methods, so that they represent mean values from several observations in many cases, but allowance must be made for the variations of standard and type.

In telegraphy, the inductance of an ordinary Western Union 140-ohm relay is about three henrys with the armature drawn well back, and nine henrys with the armature pressed against the poles; in the latter case, of course, the magnetic reluctance of the iron circuit is a minimum, and the same current in the coils causes three times as many lines to circulate through the iron. At the position of the armature in ordinary adjustment the inductance is about five henrys.

The inductance of an ordinary standard 10ω relay is from 200 to 500 millihenrys, according to the position of the armature relatively to the poles.

The inductance of an ordinary sounder is similarly from 25 to 50 millihenrys. These inductances are the values obtained with only a few milliamperes through the coils, and since the path of the induction is largely through iron, the inductance varies with the strength of the current used. Practically, however, the variation is small within the range of current at which instruments usually operate.

SUBMARINE TELEGRAPHY.

The inductance of a mirror speaking galvanometer of the ordinary type having 2,250 ohms was found to be 3·6 henrys.

TELEPHONY.

The inductances met with in the ordinary long-distance telephone apparatus are as follows:

The call bell 80 ohms and 1·4 henrys.

The magneto armature 550 ohms, and from 2·7 henrys with the plane of the coil in the line joining the poles, to 7·3 henrys when the iron core joins the poles, the plane of the coil being then at right angles to the magnetic flux.

The induction coil primary 0·28 ohm and 3·5 millihenrys.

Secondary 164 ohms, and 734 millihenrys.

The mutual inductance between the coils 60 millihenrys.

The Bell telephone receives 75 ohms, and from 75 to 100 millihenrys. The removal of the diaphragm from an ordinary telephone of this type reduces the inductance about 35 per cent. All these inductances are to currents of a few milliamperes only. As regards the inductance of aerial line wires, it is to be regretted that measurements are not yet forthcoming, and indeed the experimental determination is attended with some difficulty, owing to static capacity and imperfect insulation. In the absence of direct measurements, theory indicates that the inductance of overhead copper wires depends upon the elevation above the ground as well as upon the diameter. In the case of iron wires as used in telegraphy, the permeability of the iron enters as an additional factor. The following table of inductances for copper wires, is based upon a formula first given by Clerk Maxwell.[*] It is to be hoped that experimental evidence may shortly be collected corroborating these results:

TABLE OF INDUCTANCE OF COPPER AERIAL LINE WIRE, PER KILOMETRE AND MILE, FOR DIFFERENT DIAMETERS AND ELEVATIONS ABOVE THE GROUND.

Diameter of wire.		Elevation above ground 400 cm. or 13·1ft.		Elevation above ground 700 cm. or 23ft.		Elevation above ground 1,000 cm. or 32·8ft.		Elevation above ground 1,300 cm. or 42·7ft.	
Centimetres.	Inches.	Millihenrys or myriametres.		Millihenrys or myriametres.		Millihenrys or myriametres.		Millihenrys or myriametres.	
		per kilometre.	per mile.	per kilometre.	per mile.	per kilometre.	per mile.	per kilometre.	per mile.
0·10	0·039	1·986	3·196	2·109	3·393	2·170	3·493	2·222	3·576
0·20	0·079	1·848	2·974	1·960	3·154	2·031	3·268	2·083	3·352
0·30	0·118	1·766	2·842	1·878	3·022	1·950	3·138	2·002	3·222
0·40	0·158	1·709	2·750	1·821	2·930	1·892	3·045	1·945	3·130
0·50	0·197	1·664	2·678	1·776	2·858	1·847	3·973	1·900	3·058
0·60	0·236	1·628	2·621	1·740	2·800	1·811	2·914	1·863	2·998
0·70	0·276	1·596	2·569	1·709	2·750	1·780	2 865	1·833	2·950
0·80	0·315	1·570	2·527	1·682	2·706	1·754	2·823	1·806	2·906
0·90	0·354	1·547	2·489	1·659	2·669	1·730	2·785	1·783	2·870
1·00	0·394	1·526	2·456	1·638	2·635	1·709	2·750	1·761	2·834

The inductance of iron wires, in the absence of measurements, is almost too doubtful to justify calculation, being perhaps 10 times more than the inductance of copper wires under similar conditions. The difficulty in their case lies in assigning the proper value of permeability.

ELECTRIC LIGHT AND POWER.

Dynamos and dynamo-electric machinery are, of course, generally characterised by large inductances.

The inductance of the field magnets of a dynamo may have any value depending on the size and voltage of the machine from one henry up to 900 amperes.

The inductance of an armature may similarly vary from 20 millihenrys up to 50 henrys between brushes. One millihenry is a fair average value of the inductance of one section of an armature. Armature inductances depend not only on the strength of the measuring current, but also upon the strength of the field, and whatever influences the permeability of the core.

The inductance of an alternating transformer varies from a primary of 400 millihenrys, a secondary of one millihenry and mutually 20 millihenrys with a transformation ratio of 20, up to corresponding values perhaps 100 times as great.

APPARATUS. THE INDUCTANCE OF RUHMKORFF COILS.

The smallest medical coil in ordinary use has five millihenrys in its primary, 100 millihenrys in its secondary, and 20 millihenrys mutually between them.

A large inductance coil 19in. long and 8in. in diameter has 0·145 ohms and 13 millihenrys in its primary, 30,600 ohms and 2,000 henrys (by two concordant methods of measurement) in its secondary, and 163 henrys mutually between them.

The inductance of a mirror galvanometer may vary from a few millihenrys up to 10 or more henrys according to its resistance. Two henrys is a fair average for an astatic mirror galvanometer of 5,000 ohms.

An ordinary electric bell of 2·5 ohms resistance was found to have an inductance of 12 millihenrys.

There is one point in connection with the self and mutual inductance of induction coils and transformers, that deserves attention owing to the confusion that occasionally arises concerning it. It may be, perhaps, best represented by a numerical example. Let a closed Faraday ring of iron, 100 centimetres in mean circumference and 20 square centimetres in uniform cross-section, be closely wound with a primary coil of 2,500 turns in one layer, followed by a secondary coil of 7,500 turns, also in one layer. If now two amperes be maintained steadily through the primary, the magnetic force in the iron will be $4\pi/10$ times the ampere-turns per centimetre of the iron circuit, or $4\pi/10 \times 2 \times 2{,}500 \div 100$, or 62·85. The permeability of wrought iron at this force being, say, 250, the induction developed per square centimetre will be 250 × 62·85, or 15,713 lines, and the total induction enclosed by the primary coil, neglecting the space occupied by the wire itself, will be 20 × 15,713, or 314,250 lines, which traverse every turn of both windings. The linkages with the primary will be 2,500 × 314,250, or in round numbers 786,000,000, and referred to one ampere, half this number, or an inductance of 393 million centimetres—that is, 393 millihenrys. Similarly, the linkages of these lines with the secondary will be 2,358 millions, and per ampere of primary current 1,179 millions of centimetres mutual inductance or 1·179 henrys. Next suppose the primary current interrupted, and a current steadily established in the secondary sufficient to produce the same magnetic force in the iron, thus avoiding the complication of a changing permeability. As the secondary has three times as many turns, the current effecting this will be two-thirds of one ampere. The total induction through the iron will now be the same as before and therefore the linkages will be equally numerous. The self inductance of the secondary will be $2{,}358{,}000{,}000 \div \frac{2}{3}$, or 3,537,000,000 centimetres, that is 3·537 henrys. The mutual inductance will similarly be $786{,}000{,}000 \div \frac{2}{3}$, or 1·179 henrys as before. It will be found on carrying the reckoning to the necessary degree of accuracy, that this mutual induction, 1·179, is the square root of the product of the two self-inductances, 0·393 × 3,537.

Examination of the steps in this calculation will show that this proposition must hold for all closed magnetic circuits uniformly magnetised to the same degree when the space occupied by the windings is not taken into account. Under the opposite conditions of open and especially of short iron cores, with large winding spaces, the condition usually fails, and the mutual inductance may be greater or less than the square root of the self-inductances multiplied together.

Another reason in favour of selecting 1,000 million centimetres as the value of the practical unit or henry, is the desirability of having the time-constant of an electromagnetic circuit expressed directly in seconds by its practical units as in the case of electrostatic circuits, rather than revert to a unit of inductance that would yield the time-constant in milliseconds or other fractional period of time. The time constant of a simple electromagnetic circuit, a circuit having inductance and resistance, but negligibly small electrostatic capacity, is defined as the ratio of its inductance to its resistance—that is, of its henrys to its ohms. It is an important function, and its consideration presents some remarkable analogies between inductance and electrostatic capacity that it is interesting to trace.

Imagine an inductance coil, C, without iron to be supplied with a steady current from an E.M.F., E, of 50 volts. Let the inductance of the coil be three henrys, and its resistance 10 ohms (Fig. 2.) Ohm's law determines the strength of the current to be five amperes. Now short-circuit the terminals of the coil very suddenly by a wire across its terminals of negligible resistance. The current in the coil, C, does not stop instantly, but under the name of extra current is maintained in the coil by reason of its inductance. According to theory, the last dregs of the current will never entirely vanish from the coil, although after the first few seconds the remainder is exceedingly small. The very first instant after short-circuiting, the current continues at five amperes by its electromagnetic momentum, but being unsupported, its energy is lost thermally in overcoming the coil's resistance, and it immediately falls. In falling, the lines of force linked with the circuit and sustained by the current are drawn in, cutting the coil as they recede, thus creating a counter E.M.F. tending to prolong the current, and this process of dwindling current with reduction of opposition from the reserve of inductance descend together. The total quantity of electricity that will flow through the circuit under the conditions specified may fairly be called the charge or discharge of the coil, and it can be readily proved that this charge is equal to the quantity that would be conveyed by the initial discharging current, acting uniformly during a time equal to the time-constant of the circuit. In this case the discharge commenced at five amperes, and the time-constant is 0·3 second, so that the total discharge will be that due to the flow of this current in 0·3 seconds—that is 1·5 coulombs.

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[*] Clerk Maxwell. "Electricity and Magnetism," Second Edition, I., p. 293.

To represent the case graphically, suppose the curve of discharge in time to be plotted as in the figure. Let the axis O X be divided off into seconds, and the axis O Y into amperes. (Fig. 3.) The discharge commences at five amperes, subsides rapidly at first, but at last so slowly that an indefinitely long time must elapse before it altogether disappears. The area enclosed between the curve and the axes represents ampere-seconds or coulombs to the amount of the total charge, and the proposition just stated asserts that if the current had continued at five amperes steadily for 0·3 seconds, the area of the dotted rectangle so generated, Y D T O, would be equal to the total area enclosed between the curves and the axes prolonged to the ultimate point of union.

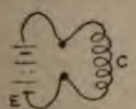

Fig. 2

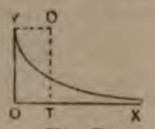

Fig. 3

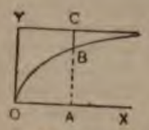

Fig. 4

Curiously enough, exactly the same law applies to the discharge of a condenser through a circuit of resistance but negligibly small inductance. The time-constant of the circuit in this case, however, being its capacity in farads multiplied by its resistance in ohms.

The curve of discharge is of the same type for inductances or capacities. It is logarithmic, and finds its prototype in the case of the discharge of water in time from a tank having a faucet at the base, assuming that the rate of escape through the faucet at any moment is directly proportional to the pressure or level of water then remaining in the tank.

The laws which control the outline of this discharge curve are identical for condensers or short-circuited inductances, and are combined in the following enunciation:

The natural logarithm of the ratio of the $\left\{\begin{array}{c}\text{full charge}\\ \text{initial current}\end{array}\right\}$ to the $\left\{\begin{array}{c}\text{residual charge}\\ \text{discharging current}\end{array}\right\}$ at any instant is the quotient of the time during which discharge has been in progress by the time-constant of the circuit.

In this statement two reservations are necessary.

The electrostatic circuit must be free from all appreciable inductance, and the electromagnetic circuit must contain negligibly small electrostatic capacity. It was first pointed out by Sir William Thomson that the discharge of a condenser through an inductance circuit, becomes oscillatory when the inductance exceeds a certain critical value.

When an inductance discharges through a break instead of a closed circuit, the conditions become complicated to a degree that eludes complete practical solution in the present state of knowledge.

At the period of natural discharge equal to the time-constant, an inductance or capacity charge or current will have fallen to 36·8 per cent. of its initial value.

Similar propositions relate to the charging currents and quantities. In the above instance, after the coil has completely discharged, remove the short-circuiting wire. The current will immediately enter the coil, and the curve of its arrival in time is represented in Fig. 4, this curve being only an inversion of the preceding. For this reason it is evident that the area above the curve now represents the charge, and by an extension of meaning, the deficit from full current, such as B C, may be called the charging current, since on discharge and reversal of the diagram, this will be the discharging current at the same lapse of time. In fact, the current A C is doing work in heating the coil, the deficit from ultimate current, B C, being only active in increasing the electromagnetic momentum of the circuit, and work is really stored in the coil as though the deficit current did exist. A similar but inverted curve of current in time represents the charge of a condenser. In each case and under the above restrictions the following propositions hold:

The natural logarithm of the ratio of the $\left\{\begin{array}{c}\text{full charge}\\ \text{initial current}\end{array}\right\}$ to the $\left\{\begin{array}{c}\text{deficit from full charge}\\ \text{charging current}\end{array}\right\}$ at any instant is the quotient of the time during which the charge has been in progress by the time-constant of the circuit.

When the charging interval reaches the time-constant, the charge will have attained 63·2 per cent. of its full value.

Another relation between simple electrostatic or electromagnetic circuits and their time-constants is in their stores of energy. The energy of the charge in each case is half the energy that would be developed by the initial charging or discharging current against the ohmic resistance of the circuit in the time equal to the time-constant. In the above instance, for example, five amperes being the initial charging or discharging current, and the resistance 10 ohms, the circuit energy of this current per second would be 5×5×10=250 joules, and during half the time-constant the energy thus developed would amount to 0·3×250÷2 or 37·5 joules. This is the electromagnetic energy stored up in the charge.

These are not the only analogies that exist between inductance and capacity, but there are remarkable points of diversity. The discharge of extra current of a coil is in the same direction as the circuit current, with the condenser it is the reverse. In a great many practical instances the electromagnet and the condenser are used to annul each other's influence.

The time-constant of an inductance circuit is generally small, for the reason that a coil of large inductance has generally many turns, and, therefore, high resistance, so that the ultimate ratio of the henrys to the ohms is not large. For example, the time-constant of a Bell telephone, considered in itself or on short circuit, is from the measurement above described about 0·09 ÷ 75 or 0·0012 seconds, and therefore a steady E.M.F. of, say, two volts, impressed directly upon such a telephone would produce in this interval of time 63·2% of 2/75 amperes—namely, 169 milliamperes. By adding inductanceless resistance to the circuit, however, and raising the E.M.F. proportionately, the time-constant would be lessened, and the arrival of current accelerated. Strictly speaking, this reasoning is inaccurate, since the telephone coil surrounds iron; but with the small currents usually employed, the iron probably does not greatly influence the arrival curve. In the case of dynamo field magnets, and large iron-clad inductances generally, the divergence of the arrival curve from that of a corresponding simple electromagnetic circuit is considerable.

There are several methods by which self and mutual inductance can be measured, the selection depending on the magnitude to be determined and its nature. The Ayrton and Perry secohmmeter, or double revolving commutator, is perhaps the most generally useful. It may be employed in connection with a standard condenser, a standard inductance, or apparent change of resistance with speed. Being used in the Wheatstone bridge, the currents it can alternate are necessary limited in strength.

For small inductances, [*]say, less than one-tenth of a millihenry, the method of Prof. Hughes,[†] or its modification by Lord Rayleigh is probably best suited, using two coils of mutual inductance and a telephone as the observing instrument.

The inductance coils are usually in the form of two concentric rings, the inner being capable of rotation about the common vertical. The mutal inductance of such a pair of coils is a complex function of the dimensions and the angle between the planes at which the coils may be set. It is usual to calibrate the instrument by separate measurements of the inductance at different angles. A simpler arrangement, however, for mutual inductance is a short solenoid in the bridge circuit superposed coaxially upon a long solenoid in the battery circuit. Adjustment to silence in the telephone for interrupted currents is then made by including in the bridge circuit a greater or less number of turns in the outer solenoid. The mutual inductance is then very nearly proportional to the number of turns so included, and by suitable proportions in construction, the accuracy can be carried as far as the telephone for the receiver will permit.

For the measurement of inductance in coils on iron machinery, the ballistic galvanometer is frequently employed, either by the method of discharge for self-inductances, or induced quantity with mutual inductances. Mutual inductances connected by closed iron circuits present no difficulty when great accuracy is not required, since, as already observed, the self-inductances are calculable in these cases with the mutual inductance, and the number of turns in the coils are known. It is much more difficult, however, to measure the self-inductance of the field magnet of a dynamo when the armature is removed, and when currents of the normal exciting strength are used in the measurement. The best attempt has been made apparently by observing the discharge effects of gradual small changes of a strong current passing through the coil, in circuit with a specially arranged Wheatstone bridge.[‡] If it were of sufficient practical importance, however, to measure such inductances with powerful currents, a recording instrument might be tried, having a very light and swiftly-moving pointer, leaving a trace of its motion on a strip of moving paper like Sir William Thomson's siphon recorder. If such a pointer were arranged to give an amplitude of movement at right angles to the paper strip, in proportion to the current traversing the coil, it would register the curve of discharge when the coil was short-circuited in the manner described above. On a sufficiently enlarged scale, corrected perhaps for residual inertia in the moving parts, this curve would give not only the total quantity of discharge, but its deviation from the logarithmic line of simple electromagnetic discharge would give the means of determining the characteristic of magnetisation in the iron.

Of far less importance than the selection of the practical inductance unit, but still well worthy of separate consideration, is the selection of appropriate symbols to represent the unit briefly. It might perhaps be advantageous to represent the henry by a capital H, and the millihenry by the plain letter h. This notation would enable such an inductance as 50 henrys to be written as 50 H, and 50 millihenry as 50 h. The microhenry occurs so seldom that it would probably not need a symbol.

All measurements of precision should employ true ohms and not legal ohms in the computations. The best existing value of the true ohm is 1·0028 legal ohms.[*]

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[*] *Journal of Institution of Electrical Engineers, London Journal*, January, 1886.

[†] For another method of measuring short inductances with an alternating current, see an article by C. Steinmetz in the *Electrical Engineer*, vol. x., Nos. 130, 131, November, 1890.

[‡] *Phil. Mag.*, Feb., 1889. Dr. Sumpner.

The correction is practically so small that it can best be carried out by altering the nominal standard temperature of the resistance coils adopted. These temperatures should be increased by 9·4deg. C. for platinum-silver, 6·5deg. C. for German silver, and 13·5deg. C. for platinoid. Thus, a resistance-box with platinum coils standardised for legal ohms (of 106·0 cm.), at 15deg. C. would give true ohms of 106·3 cm. at 24·4deg. C. as the best approximation, and this would be the standard temperature of the box for use in precise measurements of inductance.

THE ELECTROMAGNET.[†]

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E

LECTURE IV.

(Continued from page 18.)

Now, these things can be not only predicted by the help of such a law as that, but verified by experiment. Here is a set of tubular coils which we use at the Finsbury Technical College for the purpose of verifying these laws. There is one here about 9in. long, one about half that length, another just a quarter. They are all made alike in this way, that they have exactly the same weight of copper wire, cut from the same hank, upon them. There are, of course, more turns on the long one than on the shorter, because with the shorter ones each turn requires, on the average, a larger amount of wire, and, therefore, the same weight of wire will not make the same number of windings. We use that very simple apparatus, a Salter's balance, to measure the pull exerted down to different distances on cores of various lengths. You find in every case the pull increases and becomes a maximum, then diminishes. We will now make the experiment, taking first a long plunger, roughly about twice as long as the coil. The pull increases as the plunger goes down, and the maximum pull occurs just when the lower end gets to the bottom; beyond that the pull is less. Using the same plunger, with these shorter coils, one finds the same thing; in fact, more marked, for we have now a core which is more than twice the length of the coil. So we find, taking in all these cases, that the maximum pull occurs, not when the plunger is half way in, as the books say, but when the bottom end of it is just beginning to come out through the bottom of the coil that we are using. If, however, we take a shorter plunger, the result is different. Here is one just the same length as the coil With this one the maximum pull does occur when the core is about half way in; the maximum pull is just about at the middle. Again, with a very short core—here is one about one-sixth of the length of the coil—the maximum pull occurs as it is going into the mouth of the coil; and when both ends have gone in so far that it gets into the region of equable magnetic field, there is no more pull on one end than on the other: one end is trying to move with a certain force down the tube, and the other end is trying to move with exactly equal force up the tube, and the two balance one another. If we carry that to a still more extreme case, and employ a little round ball of iron to explore down the tube, you will find this curious result, that the only place where any pull occurs on the ball is just as it is going in at the mouth. For about half an inch in the neck of the coil there is a pull; but there is no pull down the interior of the tube at all, and there is no measurable pull outside.

Now these actions of the coil on the core are capable of being viewed from another standpoint. Every engineer knows that the work done by a force has to be measured by multiplying together the force and the distance through which its point of application moves forward. Here we have a varying force acting over a certain range. We ought, therefore, to take the amount of the force at each point, and multiply that by the adjacent little bit of range, averaging the force over that range, and then take the next value of force with the next little bit of range, and so consider in small portions the work done along the whole length of travel. If we call the length of travel x, the element of length must be called dx. Multiply that by f, the force. The force multiplied by the element of length gives us the work, dw, done in that short range. Now the whole work over the whole travel is made up of the sum of such elements all added together; that is to say, we have to take all the various values of f, multiply each by its own short range dx, and the sum of all those, writing $\int$ for the sum, would be equal to the sum of all the work; that is to say, the whole work done in putting the thing together will be written:

$$w = \int f\,dx.$$

Now, what I want you to think about is this: here, say, is a coil, and there is a distant core. Though there is a current in the coil it is so far away from the core that practically there is no action; bring them nearer and nearer together; presently they begin to act one on another, there is a pull, which increases as the core enters, then comes to a maximum, then dies away as the end of the core begins to protrude at the other side. There is no further pull at all when the two ends stand out equally. Now there has been a certain total amount of work done by this apparatus. Every engineer knows that if we can ascertain the force at every point along the line of travel the work done in that travel is readily expressed by the area of the force curve. Think of the curve X C X, in Fig. 61, the ordinates of which represent the forces. The whole area underneath this curve represents the work done by the system, and therefore represents equally the work you would have to do upon it in pulling the system apart. The area under the curve represents the total work done in attracting in the iron plunger, with a pull distributed over the range $X X_1$.

Now I want you to compare that with the case of an electromagnet where, instead of having this distributed pull, you have a much stronger pull over a much shorter range. I have endeavoured to contrast the two in the other curves drawn in Fig. 61. Suppose we have our coil, and suppose the core, instead of being made of one rod such as this, were made in two parts, so that they could be put together with a screw in the middle, or fastened together in any other mechanical way. Now first treat this rod as a single plunger, screw the two parts together, and begin with the operation of allowing it to enter into the coil; the work done will be the area under the curve which we have already considered. Let us then divide the iron core into two. First of all put in one end of it; it will be attracted up in a precisely similar fashion, only being a shorter bar, the maximum would be a little displaced. Let it be drawn in up to half way only; we have now a tube half filled with iron, and in doing so we shall have had a certain amount of work done by the apparatus. As the piece of iron is shorter, the force curve, which ascends from X to Y_1, will lie little lower than the curve $X C X_1$; but the area under that lower curve, which stops half way, will be the work done by the attraction of this half core. Now go to the other end and put in the other half of the iron. You now have not only the attraction of the tube, but that of the piece which is already in place, acting like an electromagnet. Beginning with a gentle attraction, it soon runs up, and draws the force curve to a tremendously steep peak, becoming a very great force when the distance asunder is very small. We have therefore in this case a totally different curve made up of two parts, a part for the putting in of the first half of the core, and a steeper part for the second; but the net result is, we have the same quantity of iron magnetised in exactly the same manner by the same quantity of electric current running round the same amount of copper wire—that is to say, the total amount of work done in these two cases is necessarily equal. Whether you allow the entire plunger to come in by a gentle pull over a long range, or whether you put the core in in two pieces—one part with a gentle pull, and the other with a sudden spring up at the end—the total work must be the same; that is to say, the total area under our two new curves must be the same as the area under the old curve. The advantage, then, of this coil and plunger method of employing iron and copper is, not that it gets any more work out of the same expenditure of energy, but that it distributes the pull over a considerable range. It does not, however, equalise it altogether over the range of travel.

A number of experimental researches have been made from time to time to elucidate the working of the coil and plunger. Hankel, in 1850, examined the relation between the pull in a given portion of the plunger and the exciting power. He found that, so long as the iron core was so thick and the exciting power so small that magnetisation of the iron never approached saturation, the pull was proportional to the square of the current, and was also proportional to the square of the number of turns of wire. Putting these two facts together we get the rule—which is true only for an unsaturated core in a given position—that the pull is proportional to the square of the ampere-turns. This might have been expected, for the magnetism of the iron core will, under the assumptions made above, be proportional to the ampere-turns, and the intensity of the magnetic field in which it is placed being also proportional to the ampere-turns, the pull, which is the product of the magnetism and of the intensity of the field, ought to be proportional to the square of the ampere-turns.

Dub, who examined cores of different thicknesses, found the attraction to vary as the square root of the diameter of the core. His own experiments show that this is inexact, and that the force is quite as nearly proportional to the diameter as to its square root. There is again reason for this. The magnetic circuit consists largely of air paths by which the magnetic lines flow from one end to the other. As the main part of the magnetic reluctance of the circuit is that of the air, anything which reduces the air reluctance increases the magnetisation, and, consequently, the pull. Now, in this case, the reluctance of the air paths is mainly governed by the surface exposed by the end portions of the iron core. Increasing these diminishes the reluctance, and increases the magnetisation by a corresponding amount. Von Waltenhofen, in 1870, compared the attraction exerted by two equal (short) tubular coils on two iron cores, one of which was a solid cylindrical rod, and the other a tube of equal length and weight, and found the tube to be more powerfully attracted. Doubtless, the effect of the increased surface in diminishing the reluctance of the magnetic circuit explains the cause of the observation.

Von Feilitzsch compared the action of a tubular coil upon a plunger of soft iron with that exerted by the same coil upon a core of hard magnetised steel of equal dimensions. The plungers, Fig. 62, were each 10·1 centimetres long; the coil being 29·5 centimetres in length, and 4·2 in diameter. The steel magnet showed a maximum attraction when it had plunged to a depth of five centimetres, whilst the iron core had its maximum at a depth of seven centimetres, doubtless because its own magnetisation went on increasing more than did that of the steel core. As the uniform field region began at a depth of about eight centimetres, and the cores were 10·1 centimetres in length, one would expect the attracting force to come to zero when the cores had plunged into a depth of about 18 centimetres. As a matter of fact, the zero point was reached a little earlier. It will be noticed that the pull at the maximum was a little greater in the case of the iron plunger.

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[*] Report of the Committee on Electrical Standards read before the British Association, September, 1890.

[†] Cantor lectures, delivered before the Society of Arts.

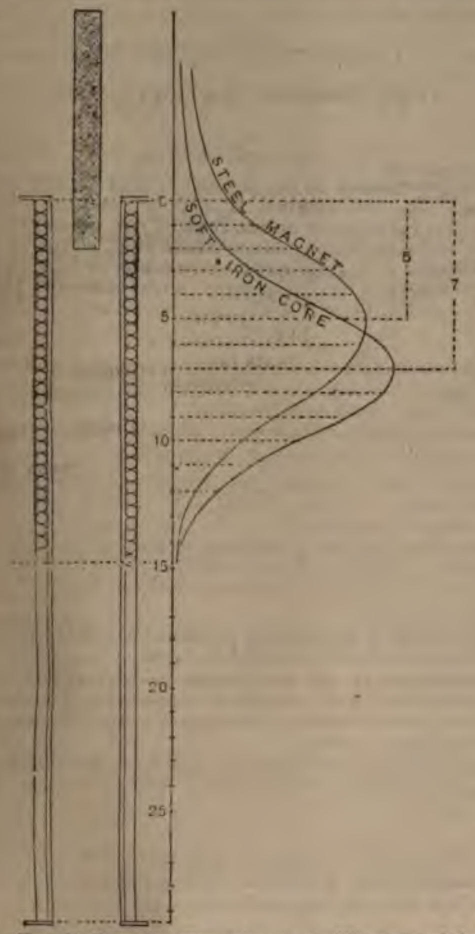

FIG. 62.—Von Feilitzsch's Experiment on Plungers of Iron and Steel.

The most careful researches of late years are those made by Dr. Theodore Bruger, in 1886. One of his researches, in which a cylindrical iron plunger was used, is represented by two of the curves in Fig. 63. He used two coils, one 3½ centimetres long, the other seven centimetres long. These are indicated in the bottom left-hand corner. The exciting current was a little over eight amperes.

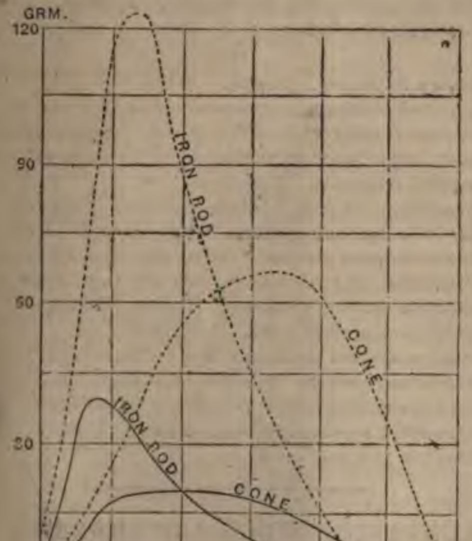

FIG. 63 Bruger's Experiments on Coils and Plungers.

The cylindrical plunger was 39 centimetres long. The plunger is supposed, in the diagram, to enter on the left, and the number of grammes of pull is plotted out opposite the position of the entering end of the plunger. As the two curves show by their steep peaks, the maximum pull occurs just when the end of the plunger begins to emerge through the coil, and the pull comes down to zero when the ends of the core protrude equally. In this figure the dotted rves relate to the use of the longer of the two coils. The height the peak, with the coil of double length, is nearly four times as great, there being double ampere-turns of excitation. In some other experiments, which are plotted in Fig. 64, the same core was used with a tubular coil 13 centimetres long. Using currents of various strengths, 1·5 ampere, 3, 4·8, 6, or 8 amperes, the pull is of course different, but, broadly, you get the same effect, that the maximum pull occurs just where the pole begins to come out at the far end of the tubular coil. There are slight differences; with the smallest amount of current the maximum is exactly over the end of tube, but with currents rather larger the maximum point comes a little farther back. When the core gets well saturated the force curve does not go on rising so far; it begins to turn over at an earlier stage, and the maximum place is necessarily displaced a little way back from the end of the tube. That was also observed by Von Waltenhofen when using the steel magnet.

EFFECT OF USING CONED PLUNGERS.

But now if, instead of employing a cylindrical core, you employ one that is pointed, you find this completely alters the position of the maximum pull, for now the point is sufficient to carry the whole of the magnetic lines which are formed in the iron rod. They do not come out at the point, but filter through, so to speak, along the sides of the core. The region where the magnetic lines come up through the iron into the air is no longer a definite "pole" at or near the end of the rod, but is distributed over a considerable surface; consequently when the point begins to poke its nose out, you still have a larger portion of iron up the tube, and the pull, instead of coming to a maximum at that position, is distributed over a wider range. I am now making the experiment roughly with my spring balance and a conical plunger, and I think you will be able to notice a marked difference between this case and that of the cylindrical plunger. The pull increases as the plunger enters, but the maximum is not so well defined with a pointed core as it is with one that is flat-ended. This essential difference between coned plungers and cylindrical ones was discovered by an engineer of the name of Krizik, who applied his discovery in the mechanism of the Pilsen arc lamps. Coned plungers were also examined by Bruger. In Fig. 63 are given the curves that correspond to the use of a coned iron core, as well as those corresponding to the use of the cylindrical iron rod. You will notice that, as compared with the cylindrical plunger, the coned core never gave so big a pull, and the maximum occurred not as the tip emerged, but when it got a very considerable way out on the other side. So it is with both the shorter and the longer coil. The dotted curves in Fig. 64 represent the behaviour of a coned plunger. With the longer coil represented, and with various currents, the maximum pull occurred when the tip had come a considerable way out; and the position of the maximum pull, instead of being brought nearer to the entering end with a high magnetising current, was actually caused to occur further down; the range of action became extended with large currents as compared with small ones. Bruger also investigated the case of cores of very irregular shapes, resembling, for example, the shank of a screw-driver, and found a very curious and irregular force curve. There is a good deal more yet to be done, I fancy, in examining this question of distributing the pull on an attracted core by altering the shape of it, but Bruger has shown us the way, and we ought not to find very much difficulty in following him.

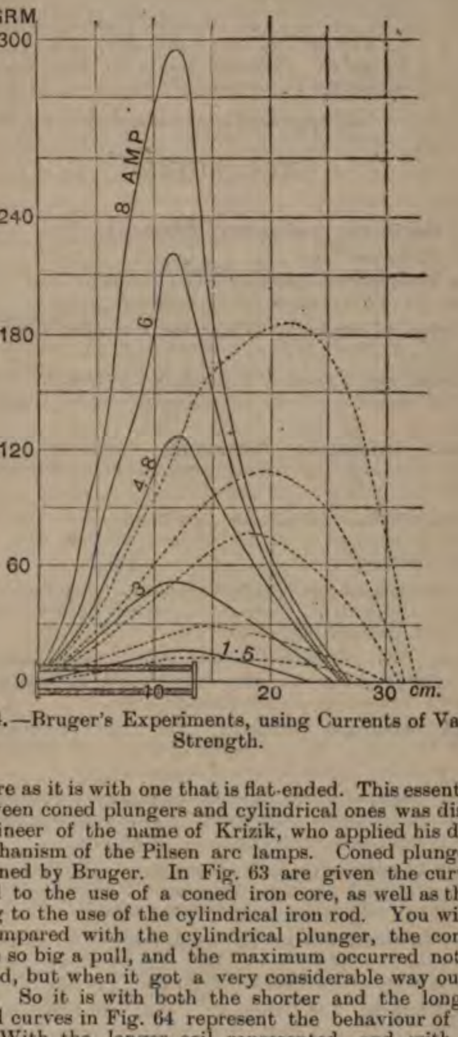

FIG. 64.—Bruger's Experiments, using Currents of Various Strength.

OTHER MODES OF EXTENDING RANGE OF ACTION.

Another way of altering the distribution of the pull is to alter the distribution of the wire on the coil. Instead of having a coned core use a coned coil, the winding being heaped up thicker at one end than at the other. Such a coil, wound in steps of increasing thickness, has been used for some years by Gaiffe, in his arc lamp; it has also been patented in Germany by Leupold. M. Trève has made the suggestion to employ an iron wire coil, so to utilise the magnetism of the iron that is carrying the current. Trève declares that such coils possess, for an equal current, four times the pulling power. I doubt whether that is so; but even if it were, we must remember that to drive any given current through an iron wire, instead of a copper wire of the same bulk, implies that we must force the current through six times the resistance; and, therefore, we shall have to employ six times the horse-power to drive the same current through the iron wire coil, so that there is really no gain.

(To be continued).

NEW COMPANIES REGISTERED.

Birmingham Telegraph Factory, Limited.—Registered by A. Mackenzie, Temple-chambers, E.C., with a capital of £50,000 in £10 shares. Object: to carry on the business of telegraph and telephone engineers and contractors and manufacturers of telegraph and telephone appliances. The first subscribers are:

	Shares.
H. Mason, Arley House, Leamington	1
E. W. Lancaster, 68, Princess-road, Edgbaston	1
P. C. Bytheway, Bank House, Wednesbury	1
J. S. Lewis, The Swifts, Yardley, near Birmingham	1
A. Mason, Arley House, Leamington	1
W. Fowler, 69, Temple-row, Birmingham	1
G. M. Fowler, Longbridge, Warwick	1

There shall not be less than two nor more than four Directors. The first are G. V. Fowler, E. W. Lancaster, and J. S. Lewis. Qualification, 50 shares. Remuneration £250, divisible, and 10 per cent. of net profits after 10 per cent. dividend.

CITY NOTES.

Great Northern Telegraph Company.—The receipts for December were £23,600.

Empire Telephone Company.—The Company has changed its offices from 60 to 171, Queen Victoria-street.

West Coast of America Telegraph Company.—The receipts for the month of December amounted to £5,375.

West India and Panama Telegraph Company.—The receipts for the half-month ended December 31 were £2,603, against £2,705.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Company for the week ended January 2 amounted to £4,668.

Cuba Submarine Telegraph Company.—For the month of December the receipts were £3,000, as compared with £2,995 for the corresponding period.

Direct United States Cable Company.—A quarterly interim dividend at the rate of 3½ per cent. per annum has been declared by the Board, payable on the 24th inst.

Personal.—Mr. William Mather, M.P., left Manchester on Saturday last for Russia. He is expected to return early in February to resume his parliamentary duties.

Eastern Telegraph Company.—The traffic receipts for the month of December were £58,058, against £56,862 in the corresponding period of 1889, or an increase of 1,196.

Eastern Extension Telegraph Company.—The receipts for December amounted to £42,382, as against £40,369 in the corresponding period, showing an increase of £3,120.

Western Counties Telephone Company.—The interest warrants on this Company's 5 per cent. debentures for the half-year ending December 31st, 1890, were posted on the 6th inst.

Direct Spanish Telegraph Company.—For the month of December the receipts were £2,130, against £2,187, or a decrease of £57 as compared with the corresponding period.

Davey, Paxman, and Company.—This firm write that they had removed to 78, Queen Victoria-street some weeks before the late fire occurred which burnt down their old City offices.

Elmore's French Company.—The share certificates of Elmore's French Patent Copper Depositing Company, Limited, are ready to be exchanged for allotment letters and all bankers' receipts.

Western and Brazilian Telegraph Company.—The traffic receipts of the Company for the week ended January 2, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,747.

The Phosphor Bronze Company.—The Company have appointed Mr. W. A. Perry, late manager of Messrs. H. H. Vivian and Co., Limited, Birmingham, manager of the Phosphor Bronze Co.'s rolling and wire-drawing mills at Aston-road and Bagot-street, Birmingham.

International Okonite Company.—The Directors state that the profits which have accrued since June enable them to declare, after payment of interest upon debentures, an interim dividend for the six months ending December 31, on the paid-up capital of the Company, at the rate of 8 per cent. per annum upon the preference shares and 10 per cent. per annum upon the ordinary shares of the Company.

PROVISIONAL PATENTS, 1891.

NOVEMBER 29, 1890.

19505. **Improvements in the method of, and in the machinery for, the manufacture of lead or metallic boxes and plates for electric accumulators, and other kinds of lead or metallic boxes, plates, tubes, rods, strips of irregular sections, or plain, ribbed, corrugated, or fluted by hydraulic pressure, in connection with lead-pipe machinery.** Alexander Wylie, Perseverance Iron Works, Johnstone, N.B.

JANUARY 1.

12. **Improvements in terminals for telephones and other purposes.** James Frederick Bennett and Ernest Parker Hides, 30, Violet Bank-road, Sheffield.

40. **Improvements in electricity meters.** George Hookham, 7, New Bartholomew-street, Birmingham.

49. **Element and process for producing constant electric currents.** Walter Wensky, 37, Chancery-lane, London. (Complete specification.)

83. **Improvements in or relating to electric guest calls or the like.** William Phillips Thompson, 6, Lord-street, Liverpool. (Alexander Striemer, United States.) (Complete specification.)

96. **Improvements in printing telegraphic apparatus.** Edmond Bardot, 6, Bream's-buildings, London.

100. **Improvements in suspension insulators for electrical conductors and electrical apparatus.** Walter Claude Johnson and Samuel Edmund Phillips, 28, Southampton-buildings, London.

105. **Improvements in lightning arresters for electric conductors.** Friedrich Haselwander, 4, South-street, Finsbury, London.

JANUARY 3.

128. **An improved means and apparatus for regulating automatically the flow of electric currents.** John Lawrence Lee, 8, Quality-court, London.

SPECIFICATIONS PUBLISHED.

1881.

5702. **Electric lamps.** Swan. 8d. (Second edition.)

1888.

2666* **Dynamo machines, etc.** Sherrin. 8d. (Amended.)
8457. **Mechanical telephones.** Millett. 8d. (Second edition.)

1889.

20244. **Electric generating machinery.** Holmes. 11d.
20991. **Electric, etc., bells.** H. P. F. and J. Jensen. 8d.

1890.

488. **Primary batteries.** Sappey. 8d.
771. **Telephone systems.** Oesterreich and Genest. 8d.
1644. **Electric traction.** Lineff. 1s. 1d. (Second edition.)
2080. **Electric car storage batteries.** Chamberlain. 11d.
2172. **Electric tell-tales.** Boardman. 8d.
10445. **Electric prod pole.** Bayly (Burton and others). 8d.
13042. **Electric railway systems.** Van Depoele. 11d.
13410. **Electric semaphores.** Stitzel and others. 8d.
13535. **Electrical alarms.** Thompson and Rew. 8d.
14260. **Electric carrier systems.** Haddan (Williams). 8d.
16534. **Electrical primers, etc.** Longsdon. 6d.
17735. **Regulators for dynamos, etc.** Cleaver and Fassold. 6d.
18034. **Electrical switch.** Redfern (Schirner). 6d.
18076. **Incandescent lamps.** Johnson (Collier). 6d.
18186. **Electrical measuring instruments.** Lake (Weston). 8d.
18247. **Electric lamps.** Andrews. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	2
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	7½

NOTES.

Lord Rayleigh has been elected an honorary member of the Institution of Civil Engineers.

"Ironmongery" has begun a series of elementary articles on dynamos, with hints as to fitting up lighting plants.

Patent Law Reform.—The London Chamber of Commerce has appointed a committee to deal with this subject.

Stockholm Contract.—We understand that Messrs. Siemens and Halske have the contract for the Stockholm lighting.

Cassel (Germany).—Messrs. Siemens and Halske are erecting a central station here. The five-wire system will be used.

South Shields.—The National Telephone Company have opened a new exchange at the Albany-chambers, King-street, South Shields.

South Gosforth.—The question of lighting South Gosforth electrically has been referred to the Highways and Lighting Committee of the Local Board.

Chiswick.—The question of running electric bells from the fire station to the men's houses cropped up at the last meeting of the Local Board, but was shelved for a time.

The British Association.—A meeting of the Executive Committee in connection with this association's visit to Cardiff was held last Saturday, at which it was announced that the guarantee fund amounted to £1,726.

Royal Society.—At the meeting of this society yesterday afternoon, Prof. J. J. Thomson, F.R.S., was to read a paper "On the Rate of Propagation of the Luminous Discharge of Electricity through a Rarefied Gas."

Birmingham and Midland Institute.—At the annual meeting of this institute, Sir Robert S. Ball, F.R.S., of Dublin, was elected president for 1891. The annual *conversazione* was held on Wednesday, and was very successful.

Central London Railway.—The revived scheme for constructing this railway proposes to extend it to Shepherd's Bush, instead of stopping at Bayswater. At Shepherd's Bush connection could be made with the North-Western line.

Weybridge.—A draft copy of the Weybridge Electric Supply Order having been laid before the Rural Sanitary Authority, they have resolved to give the Board of Trade and the promoters of the order notice that certain amendments are required.

Institution of Electrical Engineers.—At the next meeting, on Thursday, 22nd inst., at 8 p.m., a paper will be read by Major-General C. E. Webber, C.B. (Ret.), R.E., past-president, on "The Distribution of Electricity, with especial reference to the Chelsea System."

Heating of Conductors.—At a meeting of the Edinburgh Mathematical Society held last week, Mr. John M'Cowan, of University College, Dundee, read a paper on the heating of conductors by electric currents and electric distribution in conductors so heated.

Leamington.—A special meeting of the Town Council is to be held on the 10th of February, at the request of the agents for the Midland Electric Light Company, to pass a resolution in favour of their order. As the Town Council is running an order on its own account the resolution is little likely to be passed.

University College, Dundee.—On Wednesday the council met to consider the applications for the chair of engineering, rendered vacant by the removal of Prof. Ewing to Cambridge. There were some 20 applicants, and from amongst them the council appointed Mr. T. Claxton Fidler, M.I.C.E., London.

International Telegraph Tariffs.—At a Cabinet Council held at Paris on Tuesday, President Carnot signed the Bill ratifying the telegraph tariffs fixed at the International Telegraph Conference held in Paris on June 21 last, and the special agreements concluded with Germany, Russia, Belgium, Luxemburg, the Netherlands, and Switzerland.

Electric Tramway for Naples.—The Municipal Government of Naples have authorised the construction of an electric tramway from the Museo to the Capodimonte at Naples. Mr. Von Buch, of Messrs. Foote and Von Buch, has obtained a concession from the Italian Government to work the line on the series system, and the firm are now undertaking the contract.

Professor Helmholtz.—News from Berlin says that on the seventieth birthday of Prof. Helmholtz, the celebrated physicist, which falls on the 31st of August, his numerous friends and admirers have determined to present him with some mark of their esteem. The details are to be settled by a committee, consisting of Profs. Hofmann, Du Bois-Reymond, Virchow, and others.

Exhibition of Meteorological Instruments.—The Royal Meteorological Society has arranged to hold, at 25, Great George-street, Westminster, on March 17th to 20th, an exhibition of meteorological instruments, as well as photographs and drawings possessing meteorological interest. Lists of articles intended for exhibition must be with the secretary not later than the 10th February.

Making Sure.—Most people have a horror of being buried alive, and certainly the stories that occasionally crop up on the subject are sufficiently marrow-freezing. But perhaps the idea of cremation whilst in a trance is more disquieting still. We notice that the late Miss Emma Abbott, of New York, directs in her will that her body shall be tested electrically for any signs of life prior to being cremated.

Ship Lighting.—A large steam yacht of 700 tons was this week launched by Messrs. Ramage and Ferguson, of Leith, for Lord Ashburton. She is named "The Ladye Mabel," and is lighted electrically. Lord Ashburton's pleasant country seat, The Grange, Northington, near Alresford, Hants, has been most satisfactorily lighted by electricity for some years past, the new illuminant having been introduced by his Lordship's father.

Edinburgh Exhibition.—Lord Stormonth-Darling has granted a petition by the liquidator of this exhibition for the rectification of the list of contributories by the deletion of the names of those persons who agreed to subscribe to the guarantee fund, but who did not become members of the association, they having subscribed to the fund before the association was formed. It is reported that the guarantors have paid up £24,854, leaving £1,703 still due.

Dublin.—At the meeting of the Corporation on the 12th inst., the report of the Electric Light Committee on the subject of the tenders received for the lighting of the city was to have come up for confirmation. Before, however, the subject was reached, intimation was received by the Lord Mayor, who presided, of the sudden death of a member of the Council (Alderman John O'Connor), whereupon the meeting adjourned for a week as a mark of respect to the memory of the deceased.

Exeter.—A ratepayers' meeting was held last week to protest against the proposal of the Town Council to apply for a provisional order to enable them to supply the electric light, on the ground that the Council's action was more in the nature of opposition to the local company than *bonâ fide.* Resolutions were passed to the effect that it was undesirable for the Council at present to undertake the supply of electricity, and also that a memorial on the subject should be presented to the Board of Trade.

Death.—We have to record the death of a very old postal employé in the person of Mr. Wm. Stainsby, postmaster of Hartlepool, who succumbed to an attack of paralysis on Sunday last at the age of 56. Originally the representative of the British, Irish, and Magnetic Telegraph Company for many years, he, on the transference of the telegraphs to the Government in 1870, became telegraphic superintendent at West Hartlepool, and about 12 years since was appointed postmaster at West Hartlepool.

Blotting Pads.—Messrs. Hudson and Kearns, of 83, Southwark-street, S.E., have sent us one of their blotting pads, with date indicator and diary combined. Speaking from some years' experience, we can strongly recommend these very handy adjuncts of the office table.—We have also received a useful pad from Messrs. R. E. Crompton and Co., which, besides absorbing superfluous ink, contains a calendar, memoranda slips for each day, and some particulars as to weights and measures, interest tables, etc.

Electrical Advertisement.—By an odd error the description of the electrical music-hall sign was given last week as being upon the "Pavilion," instead of, as it should be, on the "Trocadero." The large sign has been erected in the form of this word at considerable expense, and the colours are changed frequently by an automatic arrangement. There have been other large electric signs put up, as, for instance, the "Tit-Bits" sign; but, so far as we are aware, there is no such automatic changing advertisement erected elsewhere.

Commissioners of Sewers.—At their meeting on Tuesday, the Commissioners referred questions connected with the City lighting to the Streets Committee, and empowered them to obtain the assistance of Mr. Preece. It was decided to obtain the services of a permanent electrical engineer to superintend the laying of mains. A letter from the Brush Company as to laying mains from Southwark Bridge to the Guildhall, and from Blackfriars Bridge to the Mansion House, was alluded to as evidence that the lighting is about to be undertaken seriously.

Glasgow.—At the last meeting of the Town Council it transpired that the Bazaar Committee had had under consideration a report by Mr. Cook recommending an expenditure of about £1,660, which would obviate the risk of the Bazaar and the City Hall being left in comparative darkness in the event of a breakdown of the present plant. The committee, in view of the fact that the Corporation were to undertake the electric lighting of the city under the electric lighting provisional order, declined to adopt the recommendation. It was stated at the Council meeting that it might be four or five years before the Corporation were able to undertake the lighting of the city by electricity.

The Telephone in Manchester.—We are informed that the Mutual Telephone Company will open the first section of their Manchester Telephone Exchange for traffic early in February, and that they hope to begin work in Liverpool soon afterwards. Orders for between 1,600 and 1,700 wires have been already obtained in Manchester, and a considerable number of orders have also been booked in Liverpool. The company hold out the inducement of a lower rental combined with a better service. They will employ metallic circuits, and devote special attention to ensuring rapid connections. The general manager is Mr. A. R. Bennett, who has had wide and varied experience in telephone work.

City and South London Railway.—Last week the weather was all in favour of this line, and consequently more passengers desired to be carried in a given time than could be dealt with, hence there was some crowding at the City station. Given slush and fog, and the traffic receipts will go up by leaps and bounds. While we wish the railway in question all success, however, we would rather not make general deductions from the above fact. The company have deposited a Bill for their Islington extension, and seek power to raise £660,000 additional capital, with further borrowing powers not exceeding £220,000. The extension is to be carried out within five years. We notice that the traffic receipts on the City-Stockwell line last week amounted to £748.

St. Pancras.—Mr. Alderman T. E. Gibb, clerk of the St. Pancras Vestry, who is nothing if not energetic, has presented a report to the Electricity Committee on the subject of the holding of an exhibition of electrical appliances at the Vestry Hall with a view of informing the parishioners generally, who will before long be in a position to avail themselves of the electric light, on questions concerning the uses of electricity for lighting purposes and motive power, and as to the most efficient and economical way of obtaining fittings and appliances. Mr. Gibb has suggested a week next month in which to hold the exhibition, and that the expenses should be defrayed by the letting of space to exhibitors, and by imposing a small charge for admission. The committee have approved the proposal conditionally upon no part of the cost being charged to the rates.

Electric Bells.—We have received a very comprehensive catalogue (eighth edition) of the various designs in electric bells and accessory fittings manufactured by the General Electric Company, of 71, Queen Victoria-street, E.C. Those who want bells of any kind, whether for household or mining use, batteries, pushes, insulated wire, indicator boards, electric alarms, induction coils, insulators, toy motors, medical batteries and apparatus, magnetic telephones, gas lighters, and a hundred and one other requisites will find them all clearly illustrated, described, and priced in this catalogue. At the end of the book (it contains sufficient pages to be thus designated) are very complete instructions, with diagrams, for fixing and connecting electric bells, which are just what our readers in the country want, and we recommend them to obtain the catalogue.

Messrs. Appleton, Burbey, and Williamson, of 91, Queen Victoria-street, E.C., have sent us their catalogue, which is issued in a novel form this year. It consists of loose sheets numbered and arranged in a letter-box, which will no doubt preserve them better than the ordinary method of binding. Further, when any alteration or addition is necessary to the catalogue, the firm will merely issue a new sheet or sheets for insertion. The paper is of extra quality and the printing and illustrations very clear. In addition to the ordinary ink reproductions of the firm's switches and fittings, we find some very pretty illustrations of lamp shades, artistic electroliers and brackets. Information is also given as to electric bells, batteries, and fittings. We may safely say that Messrs. Appleton, Burbey, and Williamson do not intend to be left behind in the race for electrical work.

West Metropolitan Tramways Company.—This company, who were authorised in 1889 to construct additional tramways in Hammersmith, Chiswick, Acton, and

Ealing, have deposited a Bill asking Parliament to extend until August, 1893, the time originally granted for the construction of these lines. Among the reasons given for this request, the company state that they are desirous of reconstructing their existing system in such a manner that all the tramways may be worked by electrical power, but that, owing to many unavoidable difficulties, the local authorities have not yet agreed to allow electrical power to be adopted. To this delay on the part of the authorities in settling the terms upon which electricity may be used, the company ascribe their failure to raise the required additional capital necessary for the extensions, although the directors have used due diligence.

Bristol.—Mr. Preece has reported to the Town Council on a scheme for lighting Bristol. He suggests that the number of arc lamps to be used should be increased from 50 at 100ft. intervals to 100 at 50ft. apart, and the illuminating power of the incandescent lights (10,000) should be considerably increased. Mr. Preece states that on a recent visit to that city he was particularly struck with the brilliant light in the streets of Florence, where the lamps were placed in the centre of the thoroughfares. He proposes that this idea should be adopted in certain wide streets and spaces in Bristol. The entire cost of the installation will be about £50,000, and Mr. Preece thinks that the cost of maintenance will not be more than 12 per cent. beyond the cost of gas, and that when the light becomes general in private use, there will be a profit of 4 per cent. This report was considered by the Electric Lighting Committee of the Council last week. A further report from the city surveyor on a site for the central station has to be considered. It really looks as if Bristol were going ahead with this matter.

Electric Block Signals.—At the Inventors' Institute on Wednesday evening, Mr. J. Grover in the chair, Mr. C. E. Spagnoletti read a paper on "The Electric Locking and Block System in use on the City and South London Electric Railway." Two stations were fitted up in the room with levers and apparatus, and Mr. Spagnoletti showed how it was impossible for either levers to be moved until the train had passed the further station. In fact, the train announced its own arrival by depressing a multiplying lever set under the rails, which being in circuit with the locking apparatus enabled the signalmen to work the signal levers again. The system has been in use for some time on a particularly dangerous portion of the Metropolitan Railway, where the junction of the Great Northern and Midland lines in a tunnel, and the inability of the signalman to see anything because his box is in a recess of the wall, render the working very difficult—and so far with satisfactory results. We hope to illustrate and describe its working on the City and South London in another issue.

City Lighting.—A City paper has worked out the following statistics: "Now that the City is within measurable distance of getting the electric light, it is interesting to learn that the present public lighting bill of the City is rather less than £10,000 a year. The future cost with electric light will be rather more than £20,000. Roughly speaking, gas lamps, of which the probable candle-power is 40,000, are to be replaced by electric lamps of 800,000 c.p. There are now in each of the three divisions about 1,000 gas lamps. They will be replaced by a gross total of about 400 arc lamps and 1,000 glow lamps. For main thoroughfares arc lamps, costing for maintenance £26 each a year, will be used; and in smaller streets, lanes, and courts, glow lamps, costing each for maintenance £5 or £10 a year. The arc lamps have each a nominal candle-power of 2,000 candles, and they will be placed at intervals of about 250ft. Midway between two arc lamps the light will be 40 times greater than midway between two existing gas lamps of 10 candles each. For private lighting both companies will use the alternating-current system."

Sunderland.—At a meeting of the Electric Lighting Committee of the Corporation, held on Tuesday, the clerk submitted a list of suggested amendments from the solicitor on behalf of the Sunderland Gas Company and the Sunderland and South Shields Water Company to the Corporation's order for supplying electricity. He stated that he had sent the amendments to the London agents of the Corporation who drew the Bill. Their reply was that they could not advise the Corporation to concede the suggested amendments, inasmuch as, when the Electric Lighting Bill was before the Board of Trade last session, gas and water companies throughout the country were allowed to send in objections and amendments, which were all duly considered. A deputation from the gas and water companies having been admitted, the town clerk drafted a resolution to the effect that the Corporation as a public authority would agree to protect as far as they could the interests of all parties concerned, and that, if the deputation could induce the Board of Trade to accept their suggested amendments to the Bill, the Corporation would not feel called upon to oppose them. This was adopted.

An Indiarubber Ring.—A telegram from Boston (U.S.), dated Jan. 12, says: "It is rumoured here that a syndicate of Englishmen and Americans, with a capital of from four to five million dollars, is being formed for the purpose of buying up all the indiarubber in the world. It is said that the syndicate already possesses the monopoly of half the Para rubber, and that it intends to operate both in Great Britain and the United States." Later telegrams, dated New York, say that the above report is regarded there as an absurd invention. About 12 months ago the indiarubber manufacturers in England combined to raise the price of rubber goods to the wholesale houses about 10 per cent. The above report is believed to be a "feeler," sent out with a view to putting the price up again to the users. It cannot be ascertained that any Englishmen are in Boston engaged in forming any such syndicate as mentioned. A competent authority on the subject says that, on the contrary, the English are interested in the concessions granted by the Government of Liberia, where rubber is equal, if not superior, to that of Para, and that the working of the existing English company will probably check any such proceedings as are reported from Boston. The whole thing is regarded as an attempt to send up the price of rubber.

Detecting Flaws.—Captain De Place, of Paris, has devised an apparatus for detecting flaws in castings which he calls the "sciséophone." It was shown in action by the inventor at Charing Cross Hotel on Wednesday last. The apparatus consists of a small pneumatic tapper worked by the hand, and with which the piece of steel or iron to be tested is tapped all over. Connected with the tapper is a telephone with a microphone interposed in the circuit. Two operators are required, one to apply the tapper and the other to listen through the telephone to the sounds produced. These operators are in separate apartments, so that the direct sounds of the taps may not disturb the listener who is to detect flaws. The two, however, are in electrical communication, so that the instant the listener hears a false sound he can signal to his colleague to mark the metal at the point of the last tap. In practice the listener sits with the telephone to his ear, and so long as the taps are normal he does nothing. Directly a false sound is heard he at once signals for the spot to be marked. By this means Captain De Place claims that he is able not only to detect a flaw, but to localise it. Tests were made in the presence of Mr. Stirling, locomotive superintendent to the S.E.R., and several engineers and others, and flaws were localised by this method. On the other hand, however, it occasionally indicated a flaw in what proved to be sound metal, so that perfection has not apparently been reached.

Telegraphists' School of Science.—Mr. H. C. Fischer presided, on Wednesday, at the fourteenth annual distribution of medals, prizes, and certificates to students in this school, which took place at the General Post Office. Mr. J. C. Lamb, secretary of the Telegraph Department, and Mr. Ardron were also present, and Mr. W. H. Preece, F.R.S., distributed the prizes. According to the report of the school 40 per cent. of the certificates in technical telegraphy, granted by the City and Guilds Institute to the schools in the United Kingdom, were awarded to the students of this school, who also obtained two or three silver medals, with money prizes, offered for competition. Sixty-three per cent. of the certificates were first class. The successes in the pure science subjects, which are supplementary to the technical section, were also very numerous, and of an equally high standard. Mr. Preece complimented Mr. Slingo, principal of the school, and his staff on the continued success of the institution and dwelt forcibly upon the value of sound technical education among the general body of the staff in assisting the British Telegraph Administration in maintaining its pre-eminent position. The chairman observed that the fact that a higher technical knowledge is now demanded of a telegraphist than in years gone by, to enable him to successfully control the present delicate and complicated apparatus, weighed heavily with the authorities in determining the recent improvements in the status and pay of the telegraph staff.

The Telephone at Plymouth.—The following is an extract from the annual report of the Plymouth Chamber of Commerce: "The subject of telephonic signalling from ships to the shore has come in several forms and on frequent occasions before the Chamber and its committees. Permission has been obtained for the signalmen of the Breakwater Fort to telephone to the agents of the various lines of mail steamers the arrival of such steamers in the Sound when, owing to the thick weather, they are not observable from the shore. It has also been arranged for all Government offices in the port, including the office of the Queen's Harbourmaster, to be connected with the telephone exchange. The Western Counties and South Wales Telephone Company has generously placed a telephone in the rooms of the Chamber, thus giving to all members communication with the exchange. Permission has also been obtained for the telephone exchange to be connected with the coast guard signal station at Rame Head, with a view to merchant ships and ships of the Navy being reported, and signals exchanged with them, from that commanding position. The Admiralty have undertaken to provide coast guard signalmen for the purpose, subject to the necessary accommodation on the spot for the coast guardsmen and their families being provided. The signal station and wires have been erected, and but for the lack of suitable lodgings for the men near the Rame Head this important work would before this have been completed. The late Commander-in-Chief at Devonport, Admiral Sir William Dowell, and his successor, H.R.H. the Duke of Edinburgh, have both interested themselves warmly in this matter, and your chairman, with Mr. F. Phillips and Mr. Daggar, recently had an interview in London with Admiral Sir G. Tryon, commanding the Naval Reserves. The present temporary and seemingly trivial obstacle will, it is probable, be soon removed."

Ipswich.—At a special meeting of the Town Council last week the Paving and Lighting Committee presented a report, which stated that two companies had applied to the Board of Trade for provisional orders—namely, the Ipswich Electricity Supply Company, Limited, of 112, Belvedere-road, London, S.E.; and Laurence, Scott, and Co., Limited, Gothic Works, King-street, Norwich. The committee had gone carefully through the orders with a representative from each company, who had respectively undertaken that certain alterations should be made in the orders in accordance with the committee's suggestions. Subject to these alterations, the committee recommended the Council to give their approval or consent to both applications. A resolution in favour of the adoption of the report having been moved, Alderman Nicholson proposed an amendment to the effect that the Council should approve of the application of Laurence, Scott, and Co. only. A long discussion then ensued, in which several members spoke in favour of this firm, some from personal experience of their work, and eventually Alderman Nicholson's amendment was carried by 13 votes to seven. A motion was then carried in favour of opposing the application of the Ipswich Supply Company. The following resolution was also passed: "That it be an instruction to the Paving and Lighting Committee to make a representation to the Board of Trade with a view of securing such a modification of the draft order as will give the Urban Sanitary Authority power to acquire the undertaking after 10 years or such other term less than 42 years as they may be advised." This was further supplemented by a motion for providing in the order for the operation of a sliding scale, making the price charged for the supply of electricity subject to the dividends paid by the company. The Paving and Lighting Committee were empowered to employ such skilled or other assistance as they might require.

Derby.—We noticed in our last issue that the Town Council had instructed Sir F. Bramwell to report as to the town being lighted electrically. He has also been asked to draw up a scheme of sewage disposal, and the following is an extract from the somewhat amusing discussion which arose on the subject of Sir F. Bramwell's appointment: Mr. Foulds said the two things, the disposal of the sewage and the electric lighting, seemed so entirely different that, unless by some marvellous combination of genius, it seemed difficult to imagine that one man could successfully deal with them both. He had always looked upon Sir Frederick as a railway engineer, but he was surprised to find that he was going to deal with sewage, and still more when he found that he was to report upon electricity. Something had appeared in the papers about dealing with sewage by electricity. He did not know whether Sir Frederick Bramwell was the author of that. He should like to know whether Sir Frederick had that special knowledge which would qualify him to deal efficiently with this subject. The Mayor: I can assure you it is so. Mr. Foulds: Then I will second the motion. Mr. Alderman Bemrose said the Council were in a peculiar position, and immediate action was necessary. If some steps were not taken within a year and eight months, the Corporation would be obliged to transfer the matter to any company who chose to come to the town. It was therefore desirable to ascertain their true position, and, as Sir Frederick Bramwell was about to make a survey of the town, to obtain a report from him as to the best mode of dealing with the electric lighting question. It would be for the Council to decide what steps should be taken when they had his report, whether to go on with the matter themselves or hand it over to a private company, but the cost by the present arrangement would be considerably less than if Sir Frederick came down specially to deal with the electric lighting. The Mayor mentioned that Sir Frederick Bramwell had been engaged in connection with electric lighting at Bedford, Leeds, Knightsbridge, and other places, and said the committee wanted to obtain their information as cheaply as possible. They, therefore, came to the conclusion that when Sir Frederick was making a survey of the streets for sewage purposes he would probably undertake this work at a reasonable cost, and his representative had informed the committee that by taking the two schemes together they had obtained a considerable reduction in the fee. The proposition was then carried.

Edinburgh and Leith.—The town clerk of Leith has lodged with the Board of Trade objections by the Corporation of Leith against the Edinburgh electric lighting provisional order, and in support of certain amendments they desire to have inserted in the order, a number of facts and considerations are submitted. It is pointed out to the Board of Trade that both Corporations having jointly acquired the undertakings of the Edinburgh Gas Light Company and the Edinburgh and Leith Gas Light Company, and a commission, composed of 16 representatives from Edinburgh and seven from Leith, having been invested with powers for lighting Edinburgh and Leith, the rates of Leith are therefore pledged similarly with those of Edinburgh to provide a guarantee fund in the event of a deficiency of funds for payment of the annuities and the interest thereon, the interest of money borrowed, and the annual sums required to be transferred to the sinking and reserve funds. It is stated that in the order Edinburgh sought to enter into a competitive undertaking, which might prove prejudicial to the interests of the gas undertaking in which the two burghs are jointly interested; that the powers sought to be conferred upon the Corporation of Edinburgh by the proposed order should not be granted without ample provision being made for the protection of the burgh of Leith from any loss which might arise from the exercise of these powers by the Corporation of Edinburgh; that the Corporation of Leith protest in the strongest possible manner against the Corporation of Edinburgh, who have a majority on the Gas Commission, having the power to transfer their electric lighting undertaking to the Gas Commissioners, and so to cast the financial and other responsibilities and consequences of the undertaking upon funds in which the burgh of Leith and city of Edinburgh are equally interested, and that the proposed power should not be granted, but that a proviso should be inserted in the order to the effect that such transfer should not be made unless agreed to by the Corporation of Leith by resolution to be passed in manner provided by the Electric Lighting (Scotland) Act, 1890; and that, in view of the proposed introduction by the Corporation of Edinburgh of a competitive method of lighting, the proposed order should provide that if at any time prior to the Corporation of Leith agreeing to a transfer to the Gas Commissioners, the Corporation of Leith consider that the price of gas supplied is higher than it would have been put but for the introduction and supply of electric light by the Corporation of Edinburgh, the Corporation of Leith may from time to time make a representation to the Board of Trade that such is the case, and the Board of Trade may direct an enquiry by a referee into the truth of the representation, and if the referee find that the price of gas is higher by reason of the exercise of the powers of the order, he shall fix the extent to which it is so affected, and shall order a corresponding reduction of the price of gas within the burgh of Leith, the gross amount of such reduction to be recoverable from the Corporation of Edinburgh by the Gas Commissioners. The proposed amendments to give effect to the above objections are also submitted. A copy of the objections and the proposed amendments have been forwarded to the town clerk of Edinburgh.

Dover.—Since our last note on the Dover lighting another Council meeting has been held, at which the following discussion took place: The Mayor said that with respect to the electric light they had had a report from Mr. Timmis, and they were still waiting for further information from him. He might remind the Council that the Corporation had obtained a provisional order, either to enable the Corporation to supply the light themselves, or to lease the concession to a company. He thought that it was advisable, before deciding what they should do, to ascertain if it were possible to obtain terms for the undertaking to be taken up by some public company. He did not propose to ask them to enter into correspondence at once with any company as to the terms on which they would undertake the matter, but he thought that while they were waiting for Mr. Timmis's further report they might employ their time in collecting information from other towns which have obtained provisional orders. They knew that a great many towns had obtained provisional orders, and it would be well to ascertain what they were doing as to supplying electric light. He would therefore move that the town clerk be instructed to enquire from the authorities in the towns which had obtained provisional orders for supplying the electric light as to what they were doing in the matter. Councillor Brown said he had no objection to second that motion, because it abstained from the declaration of any policy; the enquiry could not do any harm, although the information that they should get might not be of any great value. He thought that having allowed the gas company to acquire rights in the town, they should carefully consider matters before they allow another company to acquire control of the streets for electric lighting. Councillor Pepper said he entirely agreed that they were not entering on a new policy. They had only two possible policies—namely, to supply the light themselves, or lease the undertaking. He thought that their best advice for the present was contained in a small word of five letters—delay. Before rushing into an expenditure of which they had no clear estimate, it was necessary that they should acquire more information. He understood that they were waiting for another report of Mr. Timmis, explanatory of the other. The Town Clerk: Yes. Councillor Peake said he should support the resolution, because it harmonised with what he stated a week ago. Since they last met, Mr. Timmis's report had been severely criticised by papers that were thoroughly acquainted with electric engineering, therefore it would be well to wait before doing anything more. He thought that if they applied to towns somewhat similar to Dover—for instance, Rochester, Leamington, and Cheltenham—they would do better than by applying to the larger towns. Councillor Bradley said he was glad that they were to gather further information, for when Mr. Timmis was there he was asked to mention a town where his proposals were in operation, but was unable to do so then. Perhaps he would do so in his supplementary report. He certainly should hesitate in deciding on any policy until they had further information, especially when they read in the papers that the City of London was handing over its electric light to a company. While agreeing to a great extent with Mr. Councillor Brown as to keeping the power in their own hands as far as possible, he thought it very desirable to be fortified with further information before taking action.

INSTITUTION OF ELECTRICAL ENGINEERS.

ADDRESS OF THE PRESIDENT, WILLIAM CROOKES, F.R.S.

ELECTRICITY IN TRANSITU: FROM PLENUM TO VACUUM.

INTRODUCTION.

Whilst steadily bearing in mind that I have the honour to address a society not only of physicists, but of electrical engineers, I shall not, I hope, be out of order in venturing to call your attention to a purely abstract phase of electrical science. Numberless instances show that pure research is the abundant source from which spring endless streams of practical applications. We all know how speculative enquiry into the influence of electricity on the nervous systems of animals led to knowledge of current electricity, and ultimately to the priceless possession of the telegraph and the telephone. The abstract study of certain microscopic forms of parasitic vegetable life has enabled us to give to fermented solutions of sugar the exact flavour and aroma of the most highly-prized wines, and probably, ere long, will put us in a position to increase at will the fertility of the soil. In a different direction the same class of abstract researches applied to medical science has brought us within measurable distance of the final conquest over a large class of diseases hitherto incurable; and without egotism I may, perhaps, be allowed to say that my own researches into high vacua to some extent have contributed to the present degree of perfection of the incandescence lamp. Surely, therefore, whilst eagerly reaping and storing the harvest of practical benefits, we must not neglect to scatter more seed for future results, perchance not less wonderful and valuable.

In another respect I deviate to some extent from the course taken by many of my predecessors. I am about to treat electricity, not so much as an end in itself, but rather as a tool, by whose judicious use we may gain some addition to our scanty knowledge of the atoms and molecules of matter, and of the forms of energy which by their mutual reactions constitute the universe as it is manifest to our five senses.

I will endeavour to explain what I mean by characterising electricity as a tool. When working as a chemist in the laboratory, I find the induction spark often of great service in discriminating one element from another, also in indicating the presence of hitherto unknown elements in other bodies in quantity far too minute to be recognisable by any other means. In this way, chemists have discovered thallium, gallium, germanium, and numerous other elements. On the other hand, when examining electrical reactions in high vacua, various rare chemical elements become in turn tests for recognising the intensity and character of electric energy. Electricity, positive and negative, effect respectively different movements and luminosities. Hence the behaviour of the substances upon which electricity acts may indicate with which of these two kinds we have to deal. In other physical researches both electricity and chemistry come into play simply as means of exploration.

In submitting to you certain researches in which electricity is used as a tool, or as a means of bringing within scope of our senses phenomena that otherwise would be unrevealed, I must for a moment recall to your minds the now generally accepted theory of the constitution of matter.

KINETIC THEORY OF GASES.

Matter, at its ultimate degree of extension, is conjectured to be not continuous, but granular. Maxwell illustrates this view as follows: To a railway contractor driving a tunnel through a gravel hill, the gravel may be viewed as a continuous substance. To a worm wriggling through gravel it makes all the difference whether the creature pushes against a piece of gravel or directs its course between the interstices. To the worm, therefore, gravel seems by no means homogeneous and continuous.

With speculations as to the constitution of liquid and solid matter I need not trouble you, but will proceed at once to the third or gaseous state of matter.

The kinetic theory of gases teaches that the constituent molecules dart in every possible direction with great but continually varying velocities, coming almost ceaselessly in mutual collision with each other.* The distance each molecule traverses without hitting another molecule is known as its *free path*; the average distance traversed without collision by the whole number of molecules of a gas at any given pressure and temperature is called the *mean free path*. The molecules exert pressure in all directions, and are only restrained by gravitation from dissipating themselves into space. In ordinary gases, the length of the mean free path of the molecules is exceedingly small compared with the dimensions of the vessel, and the properties we then observe are such as constitute the ordinary gaseous state of matter, which depend upon constant collisions. But if we greatly reduce the number of molecules in a given extent of space the free path of the molecules under electric impulse is so long that the number of their mutual collisions in any given time in comparison with the number of times they fail to collide may be disregarded. Hence, the average molecule can carry out its own motions without interference. When the mean free path becomes comparable to the dimensions of the containing vessel, the attributes which constitute gaseity shrink to a minimum, the matter attains the ultra-gaseous or "radiant" state, and we arrive at a condition where molecular motions under electrical impulse can easily be studied.

The mean free path of the molecules of a gas increases so rapidly with progressive exhaustion, that whilst that of the molecules of air at the ordinary pressure is only $\frac{1}{10000}$th of a millimetre, at an exhaustion of a hundred-millionth of an atmosphere—a point (which, with present appliances, is easy to attain) corresponding to the rarefaction of the air 90 miles above the earth's surface—the mean free path will be about 30ft.; whilst at 200 miles above the earth it will be 10,000,000 miles, and millions of miles out in the depths of space it will become practically infinite. I could go on speculating in spite of Aristotle, who said: "Beyond the universe there are neither space, nor vacuum, nor time."

In discussing the motions of molecules we have to distinguish the *free* path from the *mean free path*. Nothing is yet known of the *absolute* length of the free path nor of the *absolute* velocity of a molecule. For anything we can prove to the contrary, these values may vary almost from zero to infinity. We can deal only with the *mean* free path and the *mean* velocity.

THE VACUUM PUMP.

As most of the experiments I put before you to-night are connected with high vacua, it is not out of place to refer to the pump by means of which these tubes are exhausted. Much has been said lately in recommendation of the Geissler pump and its many improvements, but I am still strongly in favour of the Sprengel, as with it I have obtained greater exhaustion than with any other. I should like to point out that the action does not stop when we cease to see air specks passing down the tubes, but continues long after this point has been passed. Neither is the non-conducting vacuum, so easily obtained by the Sprengel pump, due in any way to the presence of mercury vapour, since non-conduction can be obtained just as rapidly when special precautions have been taken to keep mercury vapour out of the tubes.

One of the great advantages of the Sprengel pump over all others lies in the fact that its internal capacity need not exceed a few cubic centimetres, and there is, therefore, much less wall surface for gases to condense upon. I have brought the very latest modification of this form of pump here to-night, and you will have an opportunity of seeing it in action and of measuring with the McLeod gauge the rarefaction it produces.*

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* I speak of "collisions," as these are the generally accepted *substrata* of the kinetic theory. But Prof. Silvanus P. Thompson reminds me that Boltzmann some years ago proposed a modification of the kinetic theory which to me seems a vast improvement on the somewhat bald notion of molecular collisions. According to Boltzmann's view, in a so-called "collision" the molecules do not actually bounce against one another, but merely fly round in two interlocking hyperbolic paths. The effect, for all external purposes, will be the same as if they collided, because of the extreme minuteness of the curved part of the paths. The gain in thus regarding the matter is that such hyperbolic paths are quite consistent with obedience to the ordinary laws of gravitational attraction, whereas the collision theory needs for its explanation that when molecules come very near together they should exhibit a repulsion varying inversely as the fifth power of the distance between them.

THE PASSAGE OF ELECTRICITY THROUGH RAREFIED GAS.

The various phenomena presented when an induction spark is made to pass through a gas at different degrees of exhaustion point to a modified condition of the matter at the highest exhaustions. Here are three exactly similar bulbs, the electrodes being aluminium balls, and the internal pressures being respectively 75 mm., 2 mm., and 0·1 mm. If I pass the induction current in succession through the bulbs, you will perceive in each case very different luminous phenomena. Here is a slightly exhausted tube, Fig. 1, like the first in the series just exhibited (75 mm.), the induction spark passes from one end to the other, A B, and the luminous discharge is seen as a line of light, acting as a flexible conductor. Under the tube I have an electro-magnet, C, and on making contact the line of light dips in the centre down to the poles of the magnet, and then rising again proceeds in a straight line. On reversing the current the line of light curves upwards. Notice that the action of the magnet in this case is only local.

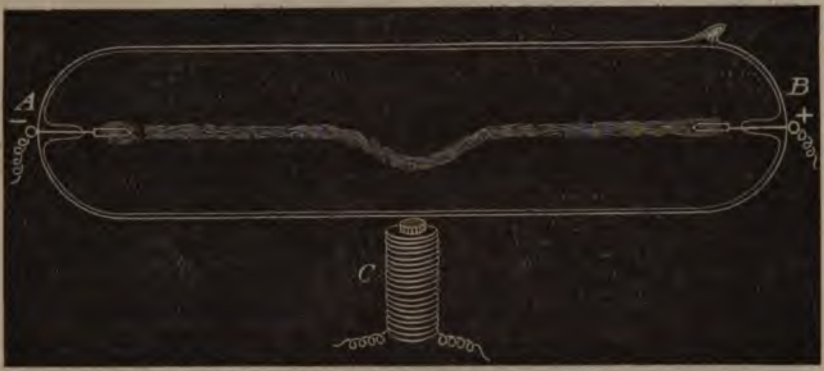

FIG. 1.—P. = 75 mm.

In a highly-exhausted tube the action is quite otherwise. Such a tube is before you, Fig. 2, and in it I have carried the exhaustion to a high point (0·1 mm.). I pass the induction current and you perceive the electrified molecules, like the line of light in the first tube, also move in straight lines, and make their path apparent by impinging on a phosphorescent screen, D E. If, however, I submit them to the action of a magnet, C, their behaviour is different. The line dips down to F, but does *not* recover itself.

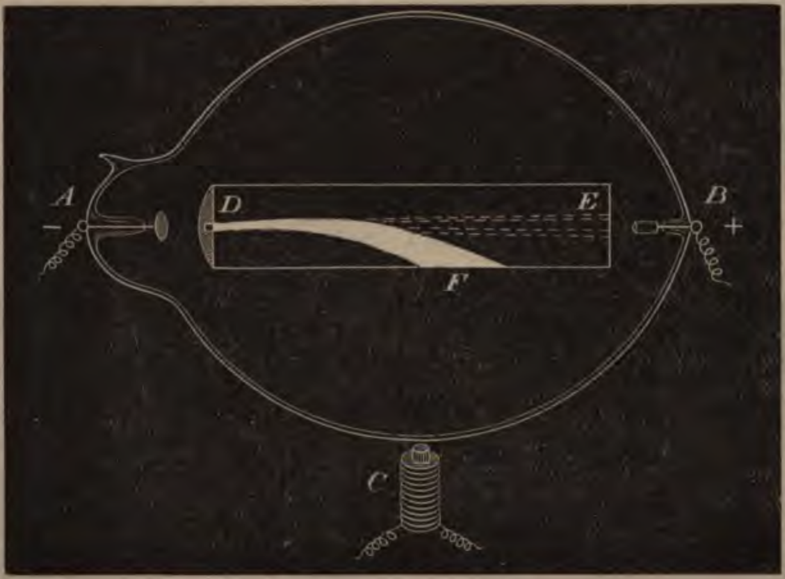

FIG. 2.—P. = 0·1 mm.   = 131·5 M.

It seems that in the tube first shown we have to do with the average behaviour of the molecules of gas in its totality. In the second case, where the gas has been greatly attenuated, we are merely concerned with the behaviour of the individual molecules of which it was originally composed.

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* My measurements of high vacua have all been taken with the beautiful little gauge devised by Prof. McLeod. Unmerited discredit has recently been cast on this gauge, the principal fault alleged being its inability to distinguish between the tension of the permanent gas and that of the mercury vapour present. Now, it is evident that under ordinary circumstances the tension of mercury vapour may be disregarded, as it will be the same on both sides of the gauge, and it will be only in cases where no mercury is present on one side of the gauge that a slight error is introduced. It is, however, very difficult to devise and successfully experiment with apparatus in which a trace of mercury vapour shall not enter, and it is not likely that an experimentalist who would be working with such mercury-free apparatus would attempt to use the gauge without remembering that in this special case the indications would be incorrect. To use the McLeod gauge requires much patience, and some amount of experience, but I have always found it trustworthy to register exhaustions far beyond the millionth of an atmosphere. I can adduce circumstantial evidence of the accuracy of its readings at these high vacua. In the year 1881 I read a paper before the Royal Society on "The Viscosity of Gases at High Exhaustions" (*Phil. Trans.*, 1881, p. 387), and illustrated my results in three large diagrams, on which I plotted the experimental results obtained at rarefactions up to the 0·02 millionth of an atmosphere, giving curves comparing the decrease in viscosity with that of the repulsion resulting from radiation, at the different pressures. Now these curves, in the case of air for instance, are perfectly regular and uniform in their falling off, and it is evident that this could not have been the case unless the abscissæ representing viscosity and the ordinates representing pressure were equally accurate. I am satisfied that, within narrow limits, the abscissæ of viscosity are correct to the highest point, and the conformity of experiment to theory in the shape of these curves is a conclusive proof that, at as high an exhaustion as 0·02 M., the McLeod gauge is to be trusted to give accurate results within 2 per cent. of the truth. To give some idea what these high exhaustions mean I may mention that the highest measured exhaustion—0·02 M.—bears the same proportion to the ordinary pressure of the atmosphere that a millimetre does to 30 miles, or in point of time, that one second bears to 20 months.

The Stratified Discharge.

When the gas is rarer than is necessary to give the flexible line of light, as shown in the first experiment, the luminosity is plainly discontinuous, or, as it is termed, stratified.

A very good illustration of this fact may be taken from the moving crowd in any much frequented street, say Fleet-street. If at some time when the stream of traffic runs almost equally in both directions, we take our stand at a window from which we can overlook the passing crowd, we shall notice that the throng on the footway is not uniformly distributed, but is made up of knots, we might almost say blocks, interrupted by spaces which are comparatively open. We may easily conceive in what manner these knots or groups are formed. Some few persons walking rather more slowly than the average rate slightly retard the movements of others whether travelling in the same or in an opposite direction. Thus a temporary obstruction is created. The passengers behind catch up to the block and increase it, and those in front, passing on unchecked at their former rate, leave a comparatively vacant space. If a crowd is moving all in the same direction the formation of these groups becomes more distinct. With vehicles in crowded streets, the result, as everyone may have remarked, will be the same.

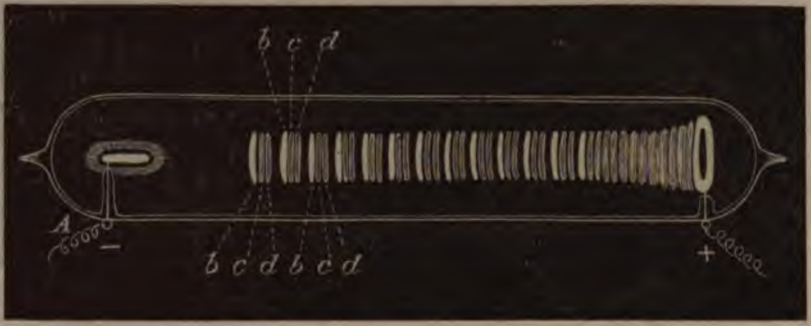

Fig. 3.—P. = 2·0 mm. = 2630·0 M.

Hence mere differences in speed suffice to resolve a multitude of passengers into alternating gaps and knots.

Instead of observing moving men and women, suppose we experiment on little particles of some substance, such as sand, approximately equal in size. If we mix the particles with water in a horizontal tube and set them in rhythmical agitation, we shall see very similar results, the powder sorting itself with regularity into alternate heaps and blank spaces.

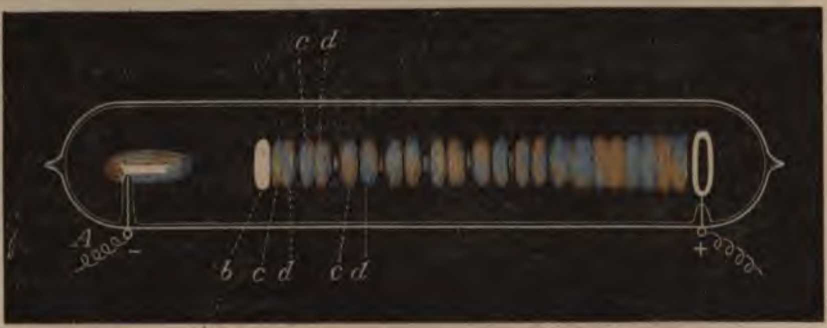

Fig. 4.—P. = 2·0 mm. = 2630·0 M.

If we pass to yet more minute substances we observe the behaviour of the molecules of a rarefied gas, when submitted to an induction current. The molecules here are free, of course, from any caprice, and simply follow the law I seek to illustrate, and though originally in a state of rampant disorder, yet under the influence of the electric rhythm they arrange themselves into well-defined groups or stratifications; the luminosities show where arrested motion with concomitant friction occurs, and the dark intervals indicate where the molecules travel with comparatively few collisions.

Parti-coloured Stratifications.

As another illustration of stratifications in a moderately exhausted tube (P. = 2 mm.), I will take the case of hydrogen prepared from zinc and sulphuric acid after being passed through various purifying agents, dried in the usual manner, and exhausted with a mercury pump, Fig. 3. I pass the induction current, and we see that the stratifications are tri-coloured, blue, pink, and grey. Next the negative pole, A, is a luminous layer, then comes a dark interval or Faraday's dark space (see below), and after this are the stratifications, the front component (*b*) of each group blue, the next (*c*) pink, and the third (*d*) grey. The blue discs are somewhat erratic. At a certain stage of exhaustion all the blue components of the stratifications suddenly migrate to the front, forming one bright blue disc, and leaving the pink and grey components by themselves. The tube before you, Fig. 4, is at this particular stage of exhaustion, and on passing the current you observe the blue disc only (*b*) is in front. When the tube contains a compound gaseous residue of this kind, the form of stratifications can be very considerably altered by varying the potential of the discharge. This alteration in the forms of stratification was first pointed out by Gassiot (1865, "B.A. Abstracts," p. 15), who gave very full descriptions and drawings of the alterations produced by putting in resistances of various lengths of distilled water. That the alteration depends simply upon the difference of potential the following experiment pretty clearly shows: Here is a tube, giving on my coil the coloured stratification usually attributed to the presence of residual hydrogen, but which I find is due to a mixture of hydrogen, mercury, and hydrocarbon vapours. Now, by altering the brake so as to produce frequent discharges of lower potential, you see the stratifications gradually change in shape and become all pink; again, altering the brake so as to send less rapid discharges at a much higher potential, once more we get the coloured stratifications. When in this state, if we introduce a water resistance into the circuit so as to damp down the potential, exactly the same thing happens. The blue disc is caused by mercury; its spectrum is that of mercury only, without even a trace of the bright red line of hydrogen. Experiments not yet finished make it very probable that the pink discs are due to hydrogen, and that the grey discs indicate carbon. The tube you have just seen contains nothing but hydrogen, mercury, and a minute trace of carbon; but with all the resources at my command I have not been able to get hydrogen quite free from impurity. Indeed, I do not think absolutely pure hydrogen has ever yet been obtained in a vacuum tube. I have so far succeeded as to completely eliminate the mercury, and almost completely to remove the trace of carbon. On the table is such a tube giving uniformly pink stratifications and showing no blue or grey discs with any potential of current.

THE DARK SPACE.

After the stratification stage is passed we come to a very curious phenomenon, the so-called "dark space." Studying electrical phenomena in gases, in the year 1838, Faraday[*] pointed out a break in the continuity of the luminous discharge separating the glow of the positive electrode from that of the negative. This he called "the dark space." It is seen in tubes containing gas only slightly rarefied, as in this tube, Fig. 5 (P. = 6 mm.), where you will observe that the positive glow, extending as a pink streak from the positive electrode, B, ends about 10 millimetres before the spot of blue light, C, representing the negative glow. This gap, or non-luminous hiatus, D, is Faraday's "dark space." Separating the negative glow from its electrode is another space. In this tube it is so small that the glow appears to be in actual contact with the electrode, but on exhausting a little further it rapidly separates; and in the next tube, Fig. 6, containing air at a little less pressure (P. = 3 mm.) this dark space, E, has extended so as to remove the negative glow about four millimetres from the electrode, A. It is with this second dark space that I particularly wish to deal to-night. Therefore I shall refer to it as the "dark space," meaning always that in the negative glow.

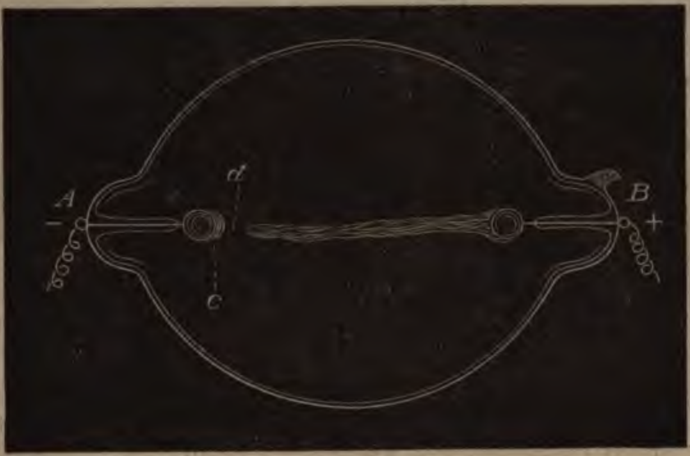

FIG. 5.—P. = 6·0 mm.

In the experiment just shown with hydrogen stratifications the contents of the tube under the electric discharge still obey the laws following from the average properties of an immense number of molecules moving in every direction with velocities of all conceivable magnitudes. But if I continue exhausting, the dark space, E, round the negative pole, A, becomes visible, grows larger and larger, and at last fills up the entire tube. The molecules at this stage are in a condition different from those in a less highly exhausted tube. At low exhaustions they behave as gas in the ordinary sense of the term, but at these high exhaustions, under electric stress, they have become exalted to an *ultra-gaseous* state, in which very decided properties, hitherto masked, come into play.

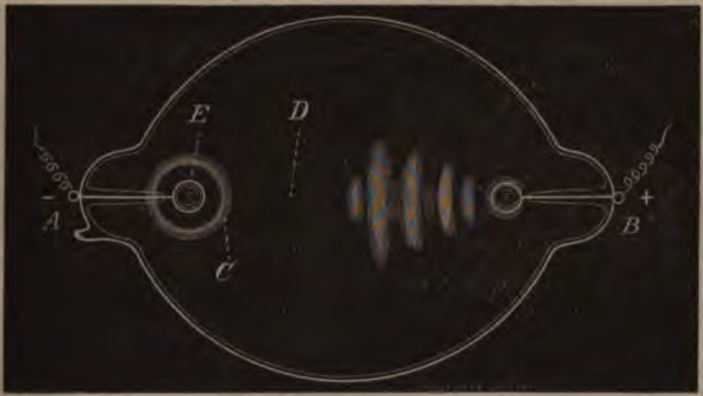

FIG. 6.—P. = 3·0 mm.

The radius of the dark space varies with the degree of exhaustion, with the kind of gas in which it has been produced, with the temperature of the negative pole, and to a less extent with the intensity of the spark.

It has been erroneously assumed that I ever said the thickness of the "dark space" represents the mean free path of the molecules in their ordinary condition, and it has been pointed out that the radius of the dark space is decidedly greater than the calculated mean free path of the molecules. I have taken accurate measurements of the radius of the dark space at different pressures, and compared it with the calculated mean free path of the gaseous molecules at corresponding pressures when not under the influence of electrical energy, and I find that they do not bear a constant relation one to the other. The length of the dark space is not 20 times the mean free pass, as some have estimated, but a gradually increasing multiple must be taken as the exhaustion becomes greater.

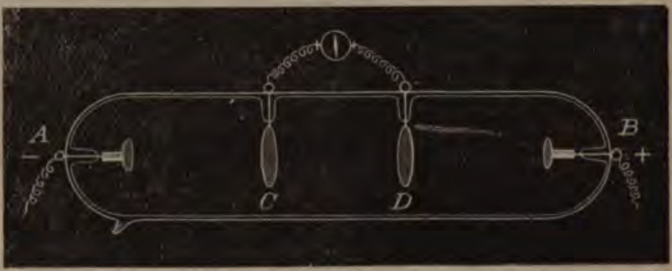

FIG. 7.

EXPLORATION WITH IDLE POLES.

Wishing to learn something of the electrical condition of the matter within and without the dark space, I made a tube, Fig. 7, having besides the positive and negative terminals, A B, two extra intermediate poles, C and D; the tube showed that when the exhaustion was such that both the idle poles were outside the dark space, on passing the current through the tube, there was a considerable difference of potential between them when measured on the galvanometer. If the exhaustion was carried so high that one of the extra poles was just on the border of the dark space, then no current passed between them. When the exhaustion was still further increased so as to enclose one of the extra poles fully in the dark space, again there was a great difference of potential between them, but the direction was reversed, the pole at highest potential now being the one formerly at lowest potential.

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[*] "Experimental Researches in Electricity," 1838, par. 1,544.

When the dark space has been further explored by means of a movable negative pole, I found that the effects did not depend essentially on the exhaustion, and were really due to the position occupied by the extra poles with regard to the dark space.

These phenomena are difficult to understand from mere description, and the experiments themselves are not easy to carry out so as to be visible to many at a time. I have here, however, a working model of an apparatus which will make these puzzling indications clear to all.

A cylindrical tube, Fig. 8, *a*, *b*, and *c* (P. = 0·25 mm.), furnished with the usual poles, A B, at the ends, has two extra or idle poles near together at C and D. The pole A is movable along the axis of the tube, so that when exhausted the dark space can be brought to any desired position with respect to the idle poles, C and D. The shading and + and − marks roughly show the distribution of positive and negative electricity inside the tube. I start with the negative pole, A, as far as possible from either idle pole, Fig. 8, *a*. Turning on the coil you see the dark space surrounding the pole A, and the idle poles quite outside.

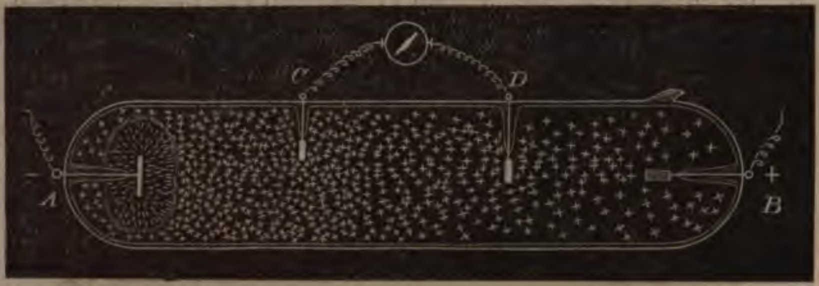

FIG. 8*a*.—P. = 0·25 mm. = 330·0 M.

The shading shows that each idle pole is in the positive area, and on testing with a gold leaf electroscope it will be seen that each is charged with positive electricity. But the shading also shows more positive at C than at D, and on connecting C and D with a galvanometer the needle indicates a rush of current from C to D, D being negative to C.

The dark space is next brought to such a position that the pole C is well within it, Fig. 8, *b*. A change has now come over the indications. The galvanometer shows a reverse current to that which was seen on the former occasion. C is now negative and D positive, but the gold leaves still tell us both poles are positively electrified.

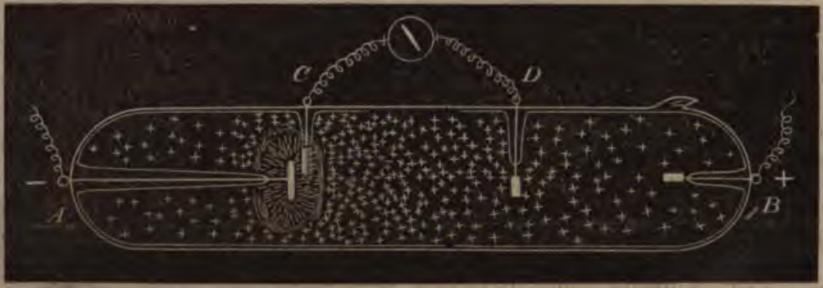

FIG. 8*b*.—P. = 0·25 mm. = 350·0 M.

At a certain position of the dark space, when its edge is on the pole C, Fig. 8, *c*, a neutral state is found at which the gold leaves still show strongly positive electrifications, and no current is seen on the galvanometer. The curves below, Fig. 8, *c*, roughly show the rise and fall of negative and positive current at different parts of the tube, whilst the potential curve keeps positive.

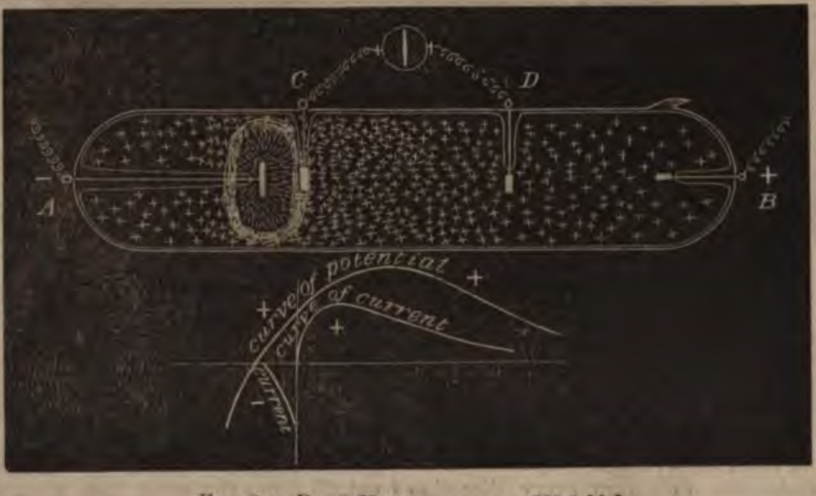

FIG. 8c.—P. = 0·25 mm. = 330·0 M.

When a substance that will phosphoresce under electrical excitement is introduced into the tube, the position of greatest luminosity is found to be at the border of the dark space, just where the two opposing armies of negative and positive atoms meet in battle array and recombine.

Later on I shall refer to this phenomenon in connection with the phosphorescence of yttria.

RADIANT MATTER.

By means of this tube, Fig. 9, I am able to show that a stream of ultra-gaseous particles, or radiant matter, does not carry a current of electricity, but consists of a succession of negatively electrified molecules whose electrostatic repulsion overbalances their electromagnetic attraction, probably because their speed along the tube is less than the velocity of light. The tube has two negative terminals, A A′, close together at one end, enabling me to send along the tube two parallel streams of radiant matter, rendered visible by impinging them through holes in a mica diaphragm on a screen of phosphorescent substance. It is exhausted to a pressure of 0·1 mm. I connect one of the negative poles, A, with the induction coil and the luminous stream darts along the tube from C to D parallel with the axis. I now connect the other negative pole, giving a second parallel stream of radiant matter. If these streams are in the nature of wires carrying a current they will attract each other, but if they are simply two streams of electrified molecules they will repel each other. As soon as the second stream is started you see the first stream jump away in the direction C E, showing strong repulsion, proving that they do not act like current carriers, but merely like similarly electrified bodies. It is, however, probable that were the velocity of the streams of molecules greater than that of light, they would behave differently and attract each other, like conductors carrying a current.

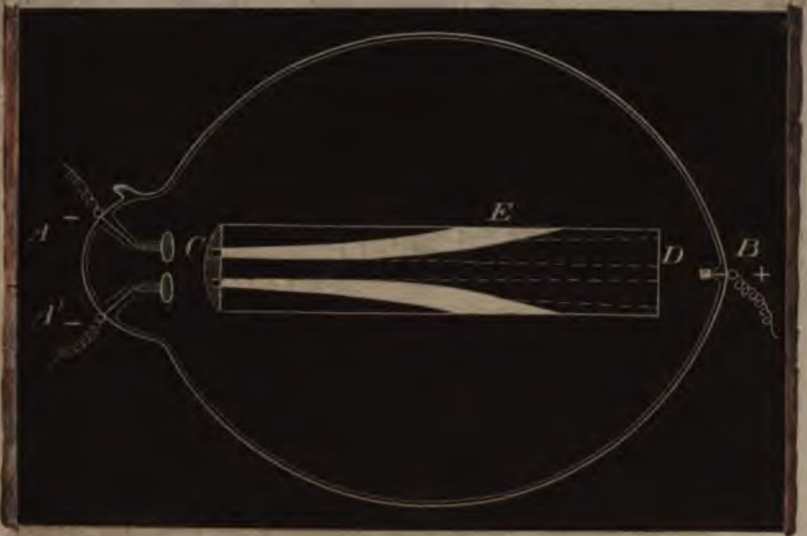

Fig. 9.—P. = 0·1 mm. = 131·5 M.

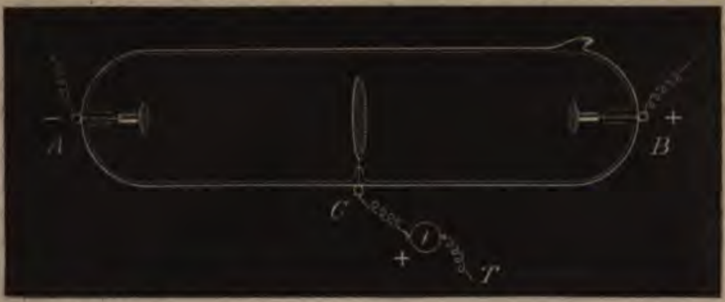

Fig. 10.—P. = 0·0001 mm. = 0·13 M.

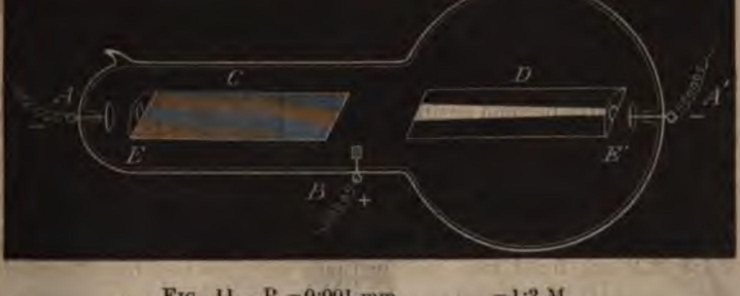

Fig. 11.—P. = 0·001 mm. = 1·3 M.

To ascertain the electrical state of the residual molecules in a highly-exhausted tube such as you have just seen, I introduced an idle pole or exploring electrode between the positive and negative electrodes in such a manner that the molecular stream might play upon it. The intention was to ascertain whether the molecules on collision with an obstacle gave off any of their electrical charge. In this experiment, Fig. 10 (P. = 0·0001 mm., or 0·13 M.*), it was found that an idle pole, C, placed in the direct line between the positive and the negative poles, A B, receiving in consequence the full impact of the molecules shot from the negative pole, manifested a strong *positive* charge. In a variety of other experiments made to decide this question the electricity obtained was always found positive on testing with the gold leaf or Lippman's electrometer, and when the idle pole was connected to earth through a galvanometer a current passed as if this pole were the copper element of a copper-zinc cell, indicating leakage of a current to earth, the idle pole being positive. If, instead of sending this current to earth, the wire was connected to the negative pole of the tube, a much more powerful current passed in the same direction.

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* M. = one-millionth of an atmosphere.
1,000,000 M. = 760 mm. 1,000,000 M. = one atmosphere.

The Edison Effect.

An exactly parallel experiment has been made by Mr. Edison, Mr. Preece, F.R.S., and Prof. Fleming, using, instead of a vacuum tube, an incandescent lamp. They found that from an idle pole placed between the ends of the filament the electricity always flowed as if the pole were the zinc element of a copper-zinc cell; having repeated their experiments I entirely corroborate them. I get a powerful current in one direction from an idle pole placed between the limbs of an incandescent carbon filament, and one in the opposite direction from an idle pole in a highly-exhausted vacuum tube. This discrepancy was extremely puzzling, and I tested, with a similar result, very many experimental tubes made in different ways. The electricity obtained from an idle pole placed between the positive and negative terminals in a highly-exhausted tube was always strongly *positive*, and it is only recently that continued experiment has cleared the matter up.

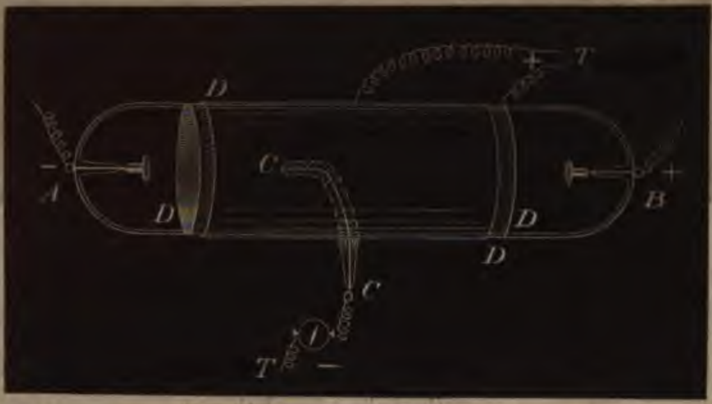

Fig. 12.—P. = 0·0001 mm. = 0·13 M.

Some of the contradictory results are due to the exhaustion not being identical in all cases. In my vacuum tubes the directions of current between the idle pole and the earth changes from negative to positive as the exhaustion rises higher. Testing the current when exhaustion is proceeding, there is a point reached when the galvanometer deflection—hitherto negative—becomes nil, showing that the potential at this point is zero. At this stage, the passage of a few more drops of mercury down the pump tube renders the current positive. This change occurs at a pressure of about 2 mm.

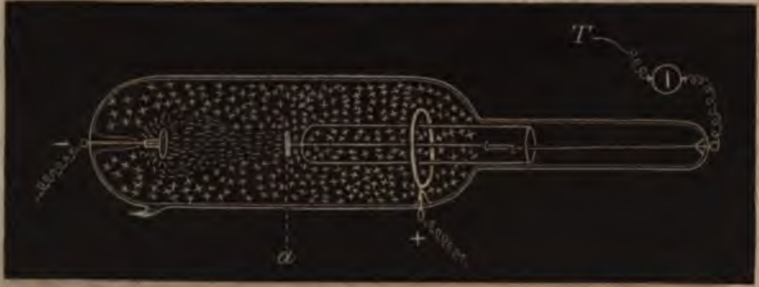

Fig. 13*a*.—P. = 0·0001 mm. = 0·13 M.

After this point is reached, when the induction current is passed through the tube, the walls rapidly become positively electrified, probably by the friction of the molecular stream against the glass, and this electrification extends over the surface of any object placed inside the tube. I will show you how this electrification of the inner walls of the tube acts on the molecular stream at high vacua. In this tube, Fig. 11 (P. = 0·001 mm. or 1·3 M.), are fixed two exactly similar phosphorescent screens, C and D; at one end of each is a mica gate, E E′, with a negative pole, A A′, facing it. One of the screens, C, is in the cylindrical part of the tube and close to the walls; the other, D, is in the spherical portion, and therefore far removed from the walls. On passing the current the screen D in the globe shows a narrow sharp streak of phosphorescence, proving that here the molecules are free to follow their normal course straight from the negative pole. In the cylindrical part of the tube, however, so great is the attraction of the walls that the molecular stream is widened out sufficiently to make the whole surface of the screen C glow with phosphorescent light.

If an idle pole, C C, Fig. 12 (P. = 0·0001 mm. or 0·13 M.), protected all but the point by a thick coating of glass, is brought into the centre of the molecular stream in front of the negative pole, A, and the whole of the inside and outside of the tube walls are coated with metal, D D, and "earthed," so as to carry away the positive electricity as rapidly as possible, then it is seen that the molecules leaving the negative pole and striking upon the idle pole C on their journey along the tube carry a negative charge, and communicate negative electricity to the idle pole.

This tube is of interest since it is the one in which I was first able to perceive how in my earlier results I always obtained a positive charge from an idle pole placed in the direct stream from the negative pole. Having got so far, it was easy to devise a form of apparatus that completely verified the theory, and at the same time threw considerably more light upon the subject. Fig. 13, *a*, *b*, *c*, is such a tube, and in this model I have endeavoured to show the electrical state of it at a high vacuum by marking a number of + and − signs. The exhaustion has been carried to 0·0001 mm., or 0·13 M., and you see that in the neighbourhood of the positive pole, and extending almost to the negative, the tube is strongly electrified with positive electricity, the negative atoms shooting out from the negative pole in a rapidly-diminishing cone. If an idle pole is placed in the position shown at Fig. 13, *a*, the impacts of positive and negative molecules are about equal, and no decided current will pass from it, through the galvanometer, to earth. This is the *neutral* point. But if we imagine the idle pole to be as at Fig. 13, *b*, then the positively electrified molecules greatly preponderate over the negative molecules, and positive electricity is shown. If the idle pole is now shifted as shown at Fig. 13, *c*, the negative molecules preponderate, and the pole will give negative electricity.

As the exhaustion proceeds, the positive charge in the tube increases, and the neutral point approaches closer to the negative pole, and at a point just short of non-conduction so greatly does the positive electrification preponderate that it is almost impossible to get negative electricity from the idle pole, unless it actually touches the negative pole. This tube is before you, and I will now proceed to show the change in direction of current by moving the idle pole.

I have not succeeded in getting the "Edison" current in incandescent lamps to change in direction at even the highest degree of exhaustion which my pump will produce. The subject requires further investigation, and, like other residual phenomena, these discrepancies promise a rich harvest of future discoveries to the experimental philosopher, just as the waste products of the chemist have often proved the source of new and valuable bodies.

PROPERTIES OF RADIANT MATTER.

One of the most characteristic attributes of radiant matter—whence its name—is that it moves in approximately straight lines, and in a direction almost normal to the surface of the electrode. If we keep the induction current passing continuously through a vacuum tube in the same direction, we can imagine two ways in which the action proceeds; either the supply of gaseous molecules at the surface of the negative pole must run short, and the phenomena come to an end, or the molecules must find some means of getting back. I will show you an experiment which reveals the molecules in the very act of returning. Here is a tube, Fig. 14, exhausted to a pressure of 0·001 mm. or 1·3 M. In the middle of the tube is a thin glass diaphragm, C, pierced with two holes, D and E. At one part of the tube a concave pole, A′, is focussed on the upper hole, D, in the diaphragm. Behind the upper hole, and in front of the lower one are movable vanes, F and G, capable of rotation by the slightest current of gas through the holes.

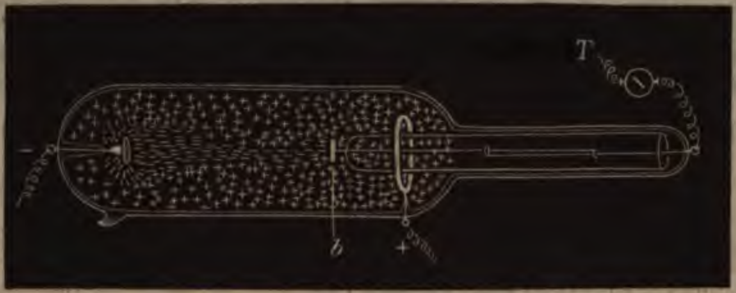

Fig. 13*b*.—P. = 0·0001 mm. = 0·13 M.

On passing the current with the concave pole negative, the small vanes rotate in such a manner as to prove that at this high exhaustion a stream of molecules issues from the lower hole in the diaphragm, whilst at the same time a stream of freshly-charged molecules is forced by the negative pole through the upper hole. The experiment speaks for itself, showing as forcibly as an experiment can show that so far the theory is right.

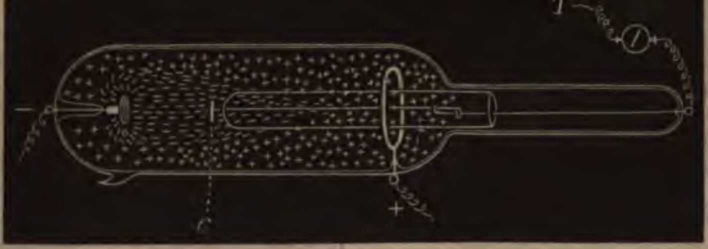

Fig. 13*c*.—P. = 0·0001 mm. = 0·13 M.

This view of the ultra-gaseous state of matter is advanced merely as a working hypothesis, which, in the present state of our knowledge, may be regarded as a necessary help to be retained only so long as it proves useful. In experimental research early hypotheses have necessarily to be modified, or adjusted, or perhaps entirely abandoned, in deference to more accurate observations. Dumas said, truly, that hypotheses were like crutches, which we throw away when we are able to walk without them.

RADIANT MATTER AND "RADIANT ELECTRODE MATTER."

In recording my investigations on the subject of radiant matter and the state of gaseous residues in high vacua under electrical strain, I must refer to certain attacks on the views I have propounded. The most important of these questionings are contained in a volume of "Physical Memoirs," selected and translated from foreign sources under the direction of the Physical Society (vol. i., part 2). This volume contains two memoirs, one by Hittorff on the "Conduction of Electricity in Gases," and the other by Puluj on "Radiant Electrode Matter and the So-called Fourth State. Dr. Puluj's paper concerns me most, as the author has set himself vigorously to the task of opposing my conclusions. Apart from my desire to keep controversial matter out of an address of this sort, time would not permit me to discuss the points raised by my critic; I will therefore only observe in passing that Dr. Puluj has no authority for linking my theory of a fourth state of matter with the highly-transcendental doctrine of four dimensional space.

Reference has already been made to the mistaken supposition that I have pronounced the thickness of the dark space in a highly-exhausted tube, through which an induction spark is passed, to be identical with the natural mean free path of the molecules of gas at that exhaustion. I could quote numerous passages from my writings to show that what I meant and said was the mean free path as amplified and modified by the electrification.* In this view I am sup-

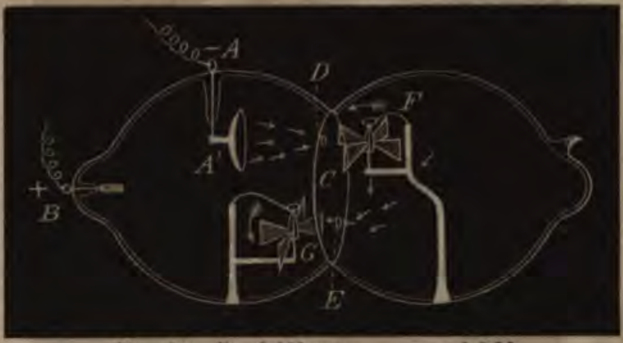

Fig. 14.—P. = 0·001 mm. = 1·3 M.

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* "The thickness of the dark space surrounding the negative pole is the measure of the mean length of the path of the gaseous molecules between successive collisions. The electrified molecules are projected from the negative pole with enormous velocity, varying, however, with the degree of exhaustion and intensity of the induction current."—(*Phil. Trans.*, part i., 1879, par. 530).

"The extra velocity with which the molecules rebound from the excited negative pole keeps back the more slowly moving molecules which are advancing towards the pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge."—(*Phil. Trans.*, part i., 1879, par. 507.)

"Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole."—(R. I. Lecture, Friday, April 4, 1879.)

ported by Prof. Schuster,* who, in a passage quoted below, distinctly admits that the mean free path of an electrified molecule may differ from that of one in its ordinary state.

The greatest difference between Puluj and myself lies in his statement that† *"the matter which fills the dark space consists of mechanically detached particles of the electrodes which are charged with statical negative electricity, and move progressively in a straight direction."*

To these mechanically detached particles of the electrodes, 'of different sizes, often large lumps,"‡ Puluj attributes all the phenomena of heat, force, and phosphorescence that I from time to time have described in my several papers.

Puluj objects energetically to my definition "radiant matter," and then proposes in its stead the misleading term, "radiant electrode matter." I say "misleading," for while both his and my definitions equally admit the existence of "radiant matter," he drags in the hypothesis that the radiant matter is actually the disintegrated material of the poles.

Puluj declares that the phenomena I have described in high vacua are produced by his irregularly shaped lumps of radiant electrode matter. My contention is that they are produced by radiant matter of the residual molecules of gas.

Were it not that in this case we can turn to experimental evidence I would not mention the subject to you. On such an occasion as this controversial matter must have no place; therefore I content myself, at present, by showing a few novel experiments which demonstratively prove my case.

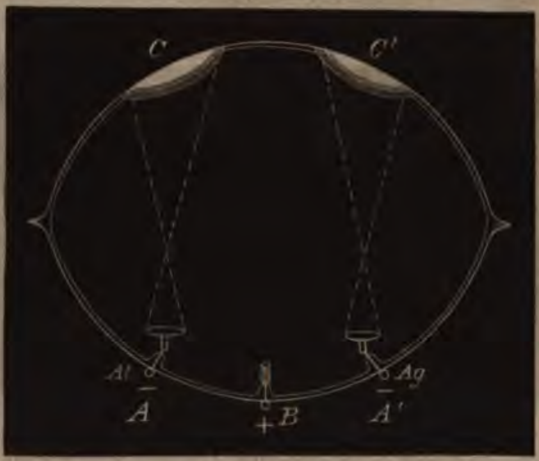

FIG. 15.—P. = 0·00068 mm. = 0·9 M

Let me first deal with the radiant electrode hypothesis. Some metals, it is well known, such as silver, gold, or platinum, when used for the negative electrode in a vacuum tube, volatilise more or less rapidly, coating any object in their neighbourhood with a very even film. On this depends the well-known method of electrically preparing small mirrors, etc. Aluminium, however, seems exempt from this volatility. Hence, and for other reasons, it is generally used for electrodes.

If, then, the phenomena in a high vacuum are due to the "electrode matter," the more volatile the metal used the greater should be the effect.§

Here is a tube, Fig. 15 (P. = 0·00068 mm., or 0·9 M.), with two negative electrodes, A A', so placed as to project two luminous spots on the phosphorescent glass of the tube. One electrode, A', is of pure silver, a volatile metal, the other, A, is of aluminium, practically non-volatile. A quantity of "electrode matter" will be shot off from the silver pole and practically none from the aluminium pole; but you see that in each case the phosphorescence, C C', is identical. Had the radiant electrode matter been the active agent the more intense phosphorescence would proceed from the more volatile pole.

A drawing of another experimental piece of apparatus is shown in Fig. 16. A pear-shaped bulb of German glass has near the small end an inner concave negative pole, A, of pure silver so mounted that its inverted image is thrown upon the opposite end of the tube. In front of this pole is a screen of mica, C, having a small hole in the centre, so that only a narrow pencil of rays from the silver pole can pass through, forming a bright spot, D, at the far end of the bulb. The exhaustion is about the same as in the previous tube, and the current has been allowed to pass continuously for many hours so as to drive off a certain portion of the silver electrode, and upon examination it is found that the silver has all been deposited in the immediate neighbourhood of the pole, whilst the spot, D, at the far end of the tube that has been continuously glowing with phosphorescent light is practically free from silver.

The experiment is too lengthy for me to repeat it here, so I shall not attempt it, but I have on the table the results for examination.

The identity of action of silver and aluminium in the first case, and the non-projection of silver in this second instance, in themselves are sufficient to condemn Dr. Puluj's hypothesis, since they prove that phosphorescence is independent of the material of the negative electrode. In front of me is a set of tubes that to my mind puts the matter wholly beyond doubt. The tubes contain no inside electrodes with the residual gaseous molecules, and with them I will proceed to give some of the most striking radiant matter experiments without any inner metallic poles at all.

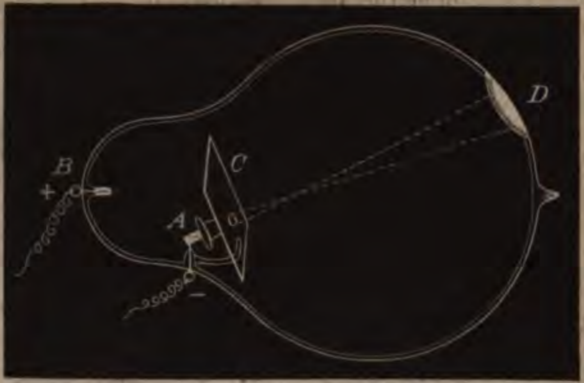

FIG. 16.—P. = 0·00068 mm. = 0·9 M.

In all these tubes the electrodes, which are of silver, are on the outside, the current acting through the body of the glass. The first tube contains gas only slightly rarefied and at the stratification stage. It is simply a closed glass cylinder, with a coat of silver deposited outside at each end, and exhausted to a pressure of 2 mm. The outline of the tube is shown in Fig. 17. I pass a current, and, as you see, the stratifications, though faint, are perfectly formed.

The next tube, seen in outline in Fig. 18, shows the dark space. Like the first, it is a closed cylinder of glass, with a central indentation forming a kind of hanging pocket, and almost dividing the tube into two compartments. This pocket, silvered on the air side, forms a

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"The electrically excited negative pole supplies the *force majeure* which entirely, or partially, changes into a rectilinear action the irregular vibration in all directions."—*Proc. Roy. Soc.*, 1880, p. 472.

"It is also probable that the absolute velocity of the molecules is increased so as to make the mean velocity with which they leave the negative pole greater than that of ordinary gaseous molecules."—(*Phil. Trans.*, part ii., 1881, par. 719.)

* "It has been suggested that the extent of the dark space represents the mean free path of the molecules. . . It has been pointed out by others that the extent of the dark space is really considerably greater than the mean free path of the molecules, calculated according to the ordinary way. My measurements make it nearly 20 times as great. This, however, is not in itself a fatal objection; for, as we have seen, the mean free path of an ion may be different from that of a molecule moving among others."—Schuster, *Proc. Roy. Soc.*, xlvii., pp. 556-7.

† "Physical Memoirs," part ii., vol. i., p. 244. The paragraph is italicised in the original.

‡ *Loc cit.*, p. 242.

§ In a valuable paper read before the Royal Society, Nov. 20, 1890, by Profs. Liveing and Dewar, on finely-divided metallic dust thrown off the surface of various electrodes in vacuum tubes, they find not only that dust, however fine, suspended in a gas will not act like gaseous matter in becoming luminous with its characteristic spectrum in an electric discharge, but that it is driven with extraordinary rapidity out of the course of the discharge.

hollow glass diaphragm that can be connected electrically from the outside, forming the negative pole, A; the two ends of the tube, also outwardly silvered, form the positive poles, B B. I pass the current, and you all see the dark space distinctly visible. The pressure here is 0·076 mm., or 100 M.

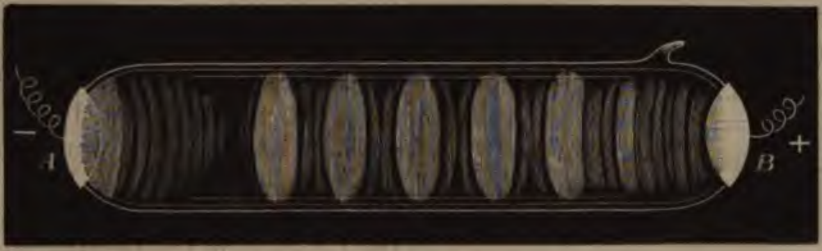

Fig. 17.—P. = 2·0 mm.

The next stage, dealing with more rarefied matter, is that of phosphorescence. Here is an egg-shaped bulb, shown in Fig. 19, containing some pure yttria, and a few rough rubies. The positive electrode, B, is on the bottom of the tube under the phosphorescent material, the negative, A, is on the upper part of the tube. See how well the rubies and yttria phosphoresce under molecular bombardment, at an internal pressure of 0·00068 mm., or 0·9 M.

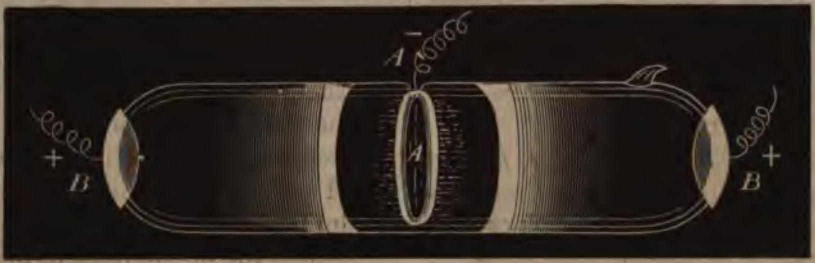

Fig. 18.—P. = 0·076 mm = 100·0 M.

A shadow of an object inside a bulb can also be projected on to the opposite wall of the bulb by means of an outside pole. A mica cross is supported in the middle of the bulb, Fig. 20, and on connecting a small silvered patch, A, on one side of the bulb with the negative pole of the induction coil, and putting the positive pole to another patch of silver, B, at the top, the opposite side of the bulb glows with a phosphorescent light, on which the black shadow of the cross seems sharply cut out. Here the internal pressure is 0·00068 mm., or 0·9 M.

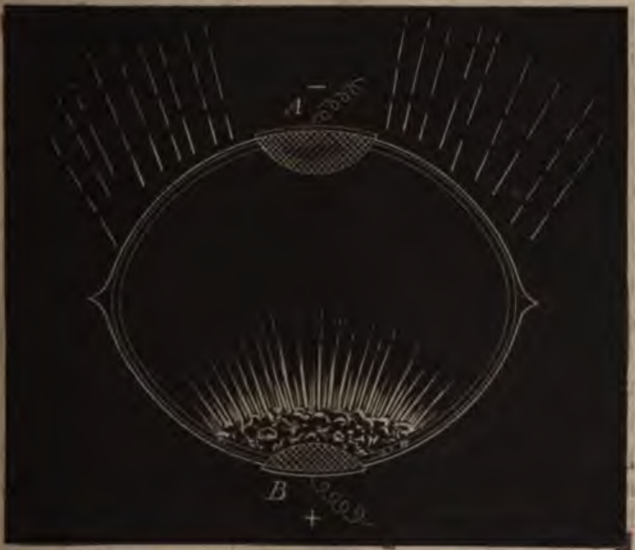

Fig. 19.—P. = 0·00068 mm. = 0·9 M.

Passing to the next phenomenon, I proceed to show the production of mechanical energy in a tube without internal poles. It is shown in Fig. 21* (P. = 0·001 mm., or 1·3 M.). It contains a light wheel of aluminium, carrying vanes of transparent mica, the poles, A B, being in such a position outside that the molecular focus falls upon the vanes on one side only. The bulb is placed in the lantern, and the image is projected on the screen; if I now pass the current you see the wheel rotates rapidly, reversing in direction as I reverse the current.

Here is an apparatus, Fig. 22*, which shows that the residual gaseous molecules when brought to a focus produce heat. It consists of a glass tube with a bulb blown at one end and a small bundle of carbon wool, C, fixed in the centre, and exhausted to pressure of 0·00076 mm., or 0·1 M. The negative electrode, A, is formed by coating part of the outside of the bulb with silver, and it is in such a position that the focus of rays falls upon the carbon wool.

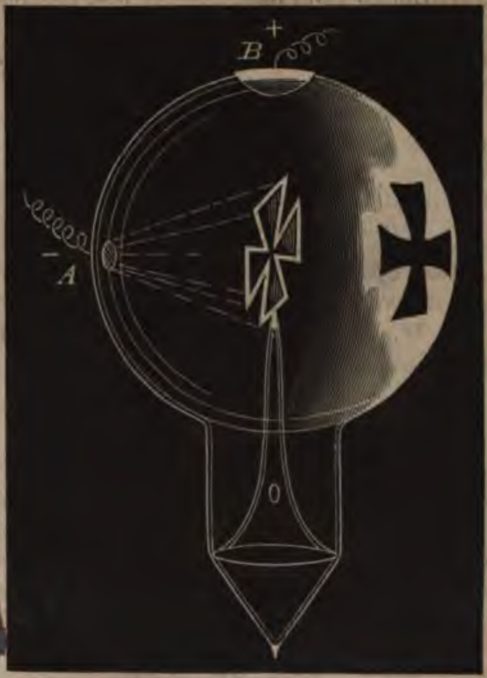

Fig. 20.—P. = 0·00068 mm. = 0·9 M.

The positive electrode, B, is an outer coating at the other end of the tube. I pass the current, and those who are close may see the bright sparks of carbon raised to incandescence by the impact of the molecular stream.

(*Continued on page 66.*)

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* Figs. 21 and 22 are given on page 66.

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1891.

In the ordinary course we should have completed our review of the past year and the forecast for the present in this issue, but we believe our readers will prefer to have the presidential address of Mr. Crookes complete rather than in instalments, so we have ventured to curtail other information for this purpose. It might be interesting to discuss the address, but really so few people have any real knowledge of the matter treated by Mr. Crookes that any criticism made thereon would serve only to show the ignorance of the critic. When other investigators have gone over the same ground as that explored by the President of the Institution, they will be able to give an opinion as to the validity of his conclusions. Meanwhile, it is better to admire his work than to criticise, and there is no doubt but that every scientific man will admire it, and credit the author with all the honour due to such a keen and brilliant investigator. Electrical engineers can appreciate the grappling with the unknown upon the boundaries of scientific knowledge even while they themselves feel the trammels of having to harness grosser matter for the purposes of their work.

Resuming our narrative, attention may be further called to the progress of transmission of power. It is admitted that here in England we hardly seem to appreciate the possibilities of distribution of power. No one can be said to be enthusiastic in its favour. Two or three tramways, one real railway, a few collieries, very little more, and all is told. In America, on the other hand, the circumstances are different, and there are in operation nearly three hundred street railways using electricity. Our hopes lie rather in the distribution of power from central stations than in the application of electricity to colliery and tramway work. The latter must come, and nothing as at present known can possibly stop it. The general introduction may be delayed, but it cannot be stopped; it may be gradual, but it will be effectual, in the long run displacing horseflesh. The very misfortune that attended the running at Birmingham ought to prove one of the strongest levers to rouse public opinion to the great cruelty to animals the use of horses on tramways perpetuates. It will be recollected that the contraction of the paving material caused a far greater pull to be required that was contemplated. The *Engineer* very pertinently remarked the horses could not speak of that unthought-of strain. The margin of safety in extra power was insufficient when electricity was employed, and had to be increased, or rather the rails have to be relaid without such possibility of contraction. We go into hysterics over some politician who has to sleep upon a plank bed, but the sentimentalists who are ready to weep and wail for something that happens in any other country are not found commiserating the cruelties practised under their noses. Two things will work for removing horse traction—the cost of buying horses will increase, as will the cost of forage. A slight rise in forage will bring electric traction to the front. As regards the South London Railway, it has been opened too recently to enable decided opinions to be given, but there is little doubt it will prove eminently successful. The demands of tramways, collieries, and railways ought to be small compared with the demand of power from central stations in every district except purely residential, and even in such districts the demand ought to be large. Is it that motors are too expensive to buy, or is it that the advantages of such apparatus are unknown to consumers? Mr. Crompton, as a rule, is pretty wideawake, and looks ahead. What is his experience at Kensington? Is there any demand for power, and has the constituency been approached on the subject? It may be taken for granted that tramway and colliery engineers know their business, and are not unaware of the claims of electricity, but the major part of the population which might use power are not in the same position of obtaining information. They do not read technical papers, and on this subject the ordinary reporter is silent. Supply companies and central station managers should consider this side of the question, and try to interest users of light to also use power.

The importance of power distribution is becoming more and more evident to those who have central installations. Arrange their plant how they will, for lighting only the cost of production per Board of Trade unit is increased at least a hundredfold, because of the inefficiency of the apparatus at low loads. In order that the production should be at the lowest possible cost, the machinery must be always working practically with a full load, and this is impossible unless the light distribution is supplemented by power distribution. The load diagram of any station will show that full load is carried only about one or two hours out of the 24. We may take it that with efficient engines and dynamos, with economical boilers and good stoking, a Board of Trade unit may be generated with the combustion of from 4·5lb. to 5lb. of coal, while we doubt if any central station can show a coal bill less than 10lb. of coal per unit generated. Thus there is just about 100 per cent. to work upon, and every addition to the load towards having full load constant is so much gain. This point is one worthy of the closest attention of those who pin their faith upon alternate-current systems and lighting only. They may find a millstone round their necks unless that much to be desired commercial alternate-current motor is forthcoming.

Appleton, Burbey, and Williamson.—During the year 1890 Messrs. Appleton, Burbey, and Williamson have been very busy manufacturing their electrical supplies for the trade, and their specialities have met with great success. Their business has so largely increased that in September they found it necessary to move their works to larger premises, and have taken a very commodious and convenient factory—viz., the Tower Bridge Electrical Works, Bermondsey. They have put down new plant and machinery, and are devoting special attention to improving the details in all electric lighting accessories. They have been especially busy with their patent switches and switchboards, the increase in this branch of their business being very marked. Recently they have commenced manufacturing electric bells, indicators, and signalling apparatus, and with special machinery for this work hope to do a large business. A new and complete price list has just been issued, and Messrs. Appleton, Burbey, and Williamson have spared no trouble to make this a useful and standard list for electrical engineers and contractors. They have considerable orders on hand, and are expecting a very busy year in 1891.

Manchester Edison-Swan Company.—This company have experienced a considerable increase in their business during 1890, 33,469 incandescent lamps having been supplied by them for the Lancashire district. In the commencement of the year they found it necessary to take additional premises in Little John-street, Manchester, on account of the increase in the manufacturing branch of their business. This, however, now proves to be inadequate, and it has been decided to move their works further out of the city, where a well-appointed and commodious factory will be built. In the installation department a large quantity of work has been carried out during the past year. Several important installations are at present in progress, among which may be mentioned 1,500 lights for the Wholesale Co-operative Society at Leicester; the lighting of the premises of the Derby Co-operative Society; the restaurant of Thos. Parker and Sons, Manchester; S. Hazzopulo's café, Brown-street, Manchester; the warehouse of Messrs. Frandenburg and Co., Greengate, Salford; the offices of the Manchester Ship Canal Company; the premises of J. Nelson, Esq., Bury; extension of the Bolton Co-operative Society installation; and the mansions of Lord Howard, of Glossop; Jos. Cliff, Esq., Brigg; J. C. Waterhouse, Esq., Prestbury; Mr. Wood, Glossop; and Jos. Wood, Esq., Chorley.

James Pitkin.—This firm are the exclusive makers of Capt. Holden's electric chronographs. These instruments, described in our issue of July 11th, 1890, are now being received with great favour, and are rapidly superseding all the older forms. They are exclusively used at the Woolwich Arsenal for measuring the velocity of projectiles as fired from large ordnance. They are also in use at the following establishments—viz., the Shoeburyness Small Arms Factory, Enfield; the Gatling Arms and Ammunition Co.; Messrs. Kynock and Co., Birmingham; Noebel's Explosives Co., Stephenson, N.B. Orders are now in hand for the Indian Government, and many other Government establishments both at home and abroad. An improved form of secondary battery is used to work the chronographs. This battery is the joint patent of Captain Holden and Mr. Pitkin. The Pitkin electric hand safety lamps are now in use at the Wigan Coal and Iron Company's collieries, the Ocean Colliery, South Wales, Cannock Chase Colliery, and several other mining companies; also at the Royal Gunpowder Factory, Waltham Abbey, Roslin Gunpowder Factory, near Edinburgh. Most of the large shipping companies use these lamps. They have also supplied a long-felt want on petroleum ships. As a safety lamp in gas works they are found to be of great service. Various forms of electrical measuring instruments have been designed and made. Among them is a very effective reflecting galvanometer of the D'Arsonval type, a simple ampere-meter, and a variable resistance. A new form of recording voltmeter is in course of construction; also a very compact little dynamo, which can be used either as a current generator or as a motor. Another of Mr. Pitkin's manufactures is Capt. Holden's open range hydrometer. This form of hydrometer is being received with much favour by users of storage batteries. Pitkin and Niblett's explosive gas detectors are found to be of much service in gas works, coal mines, ship holds, sewers, etc., or anywhere where explosive gases are liable to accumulate. Just recently a recording instrument of this type has been made. An electrically worked arrangement for communicating at a distant station the existence of dangerous accumulations of explosive gases at any given spot has been made; also an electric apparatus for giving an aural or visual alarm is in course of construction. Some other electric novelties now being introduced by this firm are an improved primary battery hand lamp, and a new magneto-electric bell and transmitter.

ADDRESS OF MR. WILLIAM CROOKES TO THE INSTITUTION OF ELECTRICAL ENGINEERS.

(Continued from page 63.)

You have thus seen that all the old "radiant matter" effects can be produced in tubes containing no metallic electrodes to volatilise. It may be suggested that the sides of the tube in contact with the outside poles become electrodes in this case, and that particles of the glass itself may be torn off and projected across and so produce the effects. This is a strong argument, which fortunately can be tested by experiment. In the case of this tube, Fig. 23 (P. = 0·00068 mm., or 0·9 M.), the bulb is made of lead glass phosphorescing blue under molecular bombardment. Inside the bulb, completely covering the part that would form the negative pole, A, I have painted a substantial coat of yttria so as to interpose a layer of this earth between the glass and the inside of the tube. The negative and positive poles are silver discs on the outside of the bulb, A being the negative and B the positive pole. If, therefore, particles are torn off and projected across the tube to cause phosphorescence, these particles will not be particles of glass, but yttria, and the spot of phosphorescent light, C, on the opposite side of the bulb will not be the dull blue of lead glass, but the golden yellow of yttria. You see there is no such indication; the glass phosphoresces with its usual blue glow, and there is no evidence that a single particle of yttria is striking it.

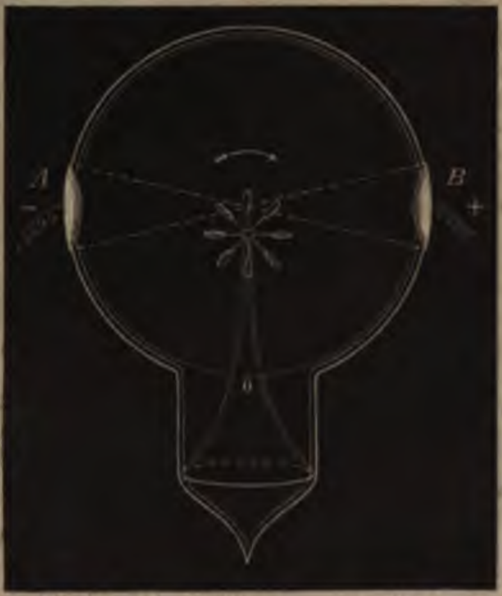


FIG. 21.—P. = 0·001 mm. = 1·3 M.

Witnessing these effects I think you will agree I am justified in adhering to my original theory that the phenomena a[illegible]d by the radiant matter of the residual gaseous molecules, and certainly not by the torn-off particles of the negative electrode.

PHOSPHORESCENCE IN HIGH VACUA.

I have already pointed out that the molecular motions rendered visible in a vacuum tube are not the motions of molecules under ordinary condition, but are compounded of these ordinary or kinetic motions, and the extra motion due to the electrical impetus.

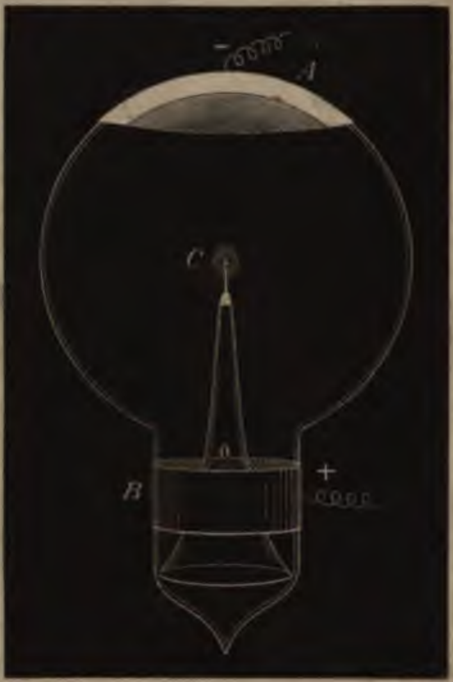


FIG. 22.—P. = 0·000076 mm. = 0·1 M.

Experiments show that in such tubes a few molecules may traverse more than a hundred times the *mean* free path, with a correspondingly increased velocity, until they are arrested by collisions. Indeed, the molecular free path may vary in one and the same tube, and at one and the same degree of exhaustion.

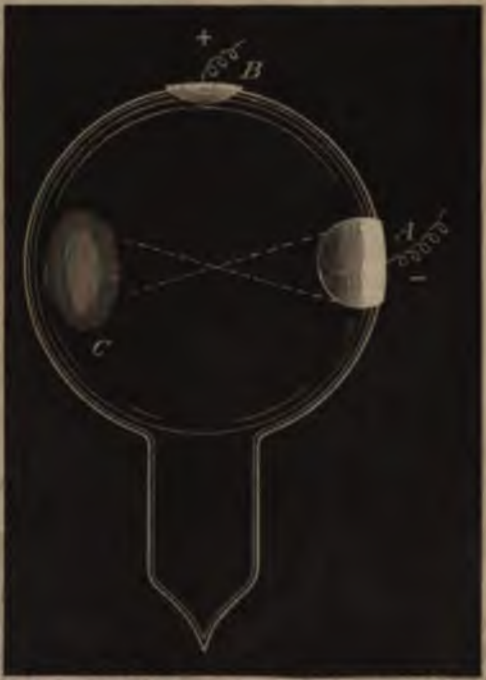


FIG. 23.—P. = 0·00068 mm. = 0·9 M.

Very many bodies, such as ruby, diamond, emerald, alumina, yttria, samaria, and a large class of earthy oxides and sulphides, phosphoresce in vacuum tubes when placed in the path of the stream of electrified molecules proceeding from the negative pole. The composition of the gaseous residue present does not affect phosphorescence; thus, the earth yttria phosphoresces well in the residual vacua of atmospheric air, of oxygen, nitrogen, carbonic anhydride, hydrogen, iodine, sulphur, and mercury.

With yttria in a vacuum tube, the point of maximum phosphorescence, as I have already pointed out, lies on the margin of the dark space. The diagram, Fig. 24, shows approximately the degree of phosphorescence in different parts of a tube at an internal pressure of 0·25 mm., or 330 M. On the top you see the positive and negative poles, A and B, the latter having the outline of the dark space shown by a dotted line, C. The curve, D E F, shows the relative intensities of the phosphorescence at different distances from the negative pole, and the position inside the dark space at which phosphorescence does not occur. The height of the curve represents the degree of phosphorescence. The most decisive effects of phosphorescence are reached by making the tube so large that the walls are outside the dark space, whilst the material submitted to experiment is placed just at the edge of the dark space.

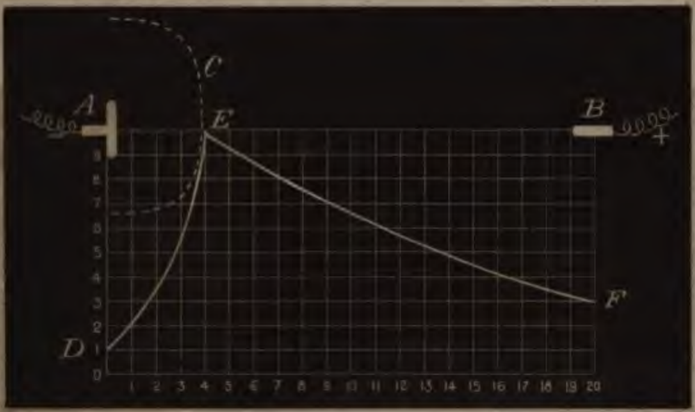


Fig. 24.—P. = 0·25 mm. = 330·0 M.

Hitherto I have spoken only of phosphorescence of substances placed under the negative pole. But from numerous experiments I find that bodies will phosphoresce in actual contact with the negative pole.

This is only a temporary phenomenon, and ceases entirely when the exhaustion is pushed to a very high point. The experiment is one scarcely possible to exhibit to an audience, so I must content myself with describing it. A U-tube, shown in Fig. 25, has a flat aluminium pole, in the form of a disc, at each end, both coated with a paint of phosphorescent yttria. As the rarefaction approaches about 0·5 mm. the surface of the negative pole, A, becomes faintly phosphorescent. On continuing the exhaustion this luminosity rapidly diminishes, not only in intensity, but in extent, contracting more and more from the edge of the disc, until ultimately it is visible only as a bright spot in the centre. This fact does not prop a recent theory, that as the exhaustion gets higher the discharge leaves the centre of the pole, and takes place only between the edge and the walls of the tube.

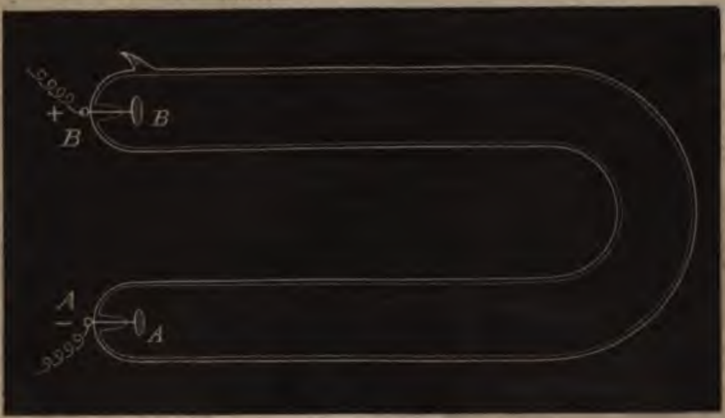


Fig. 25.

If the exhaustion is further pushed, then at the point where the surface of the negative pole ceases to be luminous, the material on the positive pole, B, commences to phosphoresce, increasing in intensity until the tube refuses to conduct, its greatest brilliancy being just short of this degree of exhaustion. The probable explanation is that the vagrant molecules I introduce in the next experiment, happening to come within the sphere of influence of the positive pole, rush violently to it and excite phosphorescence in the yttria, whilst losing their negative charge.

Loose and Erratic Molecules.

In the brief time left to me this evening I cannot touch upon the mass of experiments made to render this result clear, so I will at once show you a piece of apparatus that clearly illustrates the cause of phosphorescence at the positive pole. A drawing of this tube is shown at Fig. 26, but let me first explain the effect I expect to obtain, and then endeavour to show the actual experiment.

A C B is a U-shaped tube with terminals, A and B, at each end; D and E are two mica screens covered with a phosphorescent powder, having at F and G other screens with a small slit in front, so as to allow only a narrow beam of charged molecules to pass through. At first the tube is exhausted to a pressure of 0·076 mm. or 100 M., and you see how sharp and slightly divergent is the luminous image on screen D, whilst not a trace of phosphorescence is to be seen on the screen E in the other limb of the tube. Now I push the exhaustion to the highest point short of non-conduction (0·000076 mm., or 0·1 M.), and the phenomena change. The initial line of light on D becomes wider and unsteady, whilst at the gate, G, a decided phosphorescence is observable entering the second screen, E. This luminosity diverges to a considerable extent, much more than did the stream of charged molecules observed in the first limb of the tube at the lower exhaustion. This is only to be expected, inasmuch as those sparse molecules which have run the gauntlet of the crowd and have been hunted and buffetted round the corner will have little or no lateral support, but wander to the furthest part of the tube, and altogether behave differently to the orderly procession of molecules at more moderate exhaustion.

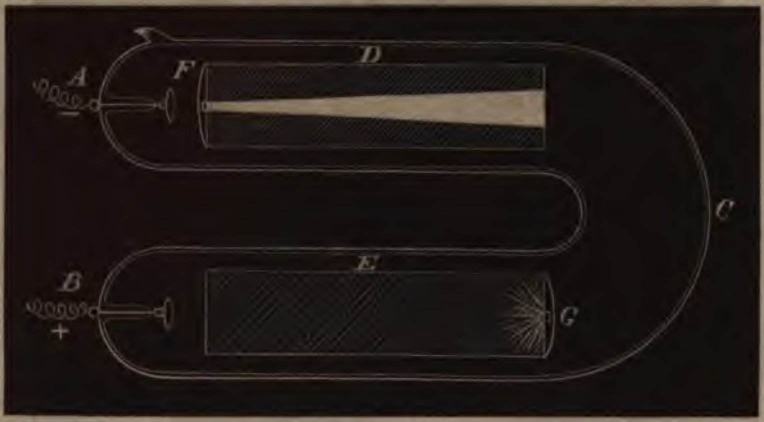
THE RESISTANCE OF HIGH VACUA.

I must only lightly touch this phenomenon to-night; it is a subject of deep interest, and one to which I have lately devoted much time. Shortly I hope to publish a full account of results recently obtained.

The passage of an induction current at a high vacuum through a tube depends much upon the material of the tube or the substance enclosed within it. Given the same degree of exhaustion, and the same distance between the terminals inside the tube, the E.M.F. necessary to force the current through may vary from 3,000 volts to 20,000 volts, according to the particular material used.

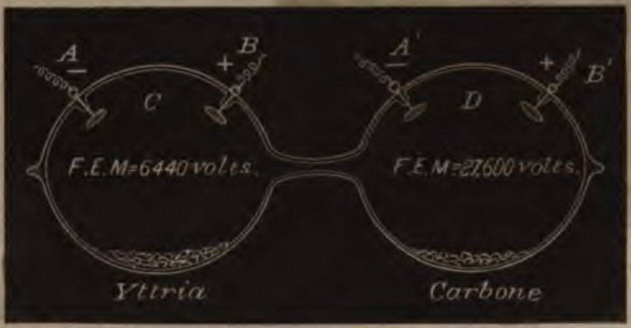
Here is a very striking example that will serve to illustrate this phenomenon. Fig. 27 is a double tube joined by a narrow open channel and therefore in the same state of exhaustion throughout (P. = 0·02 mm., or 26 M.). Each tube is furnished with a pair of poles, A B and A′ B′. One tube contains the phosphorescent earth yttria, the other contains finely-divided carbon. I first connect the yttria tube, C, to the coil, and place in parallel circuit with it a spark gauge. To begin with, this gauge is set to a gap of 1 mm. (An E.M.F. of 920 volts is necessary to strike across 1 mm. of air; therefore the difference of potential at the terminals inside the yttria tube is 920 volts, and this you perceive is not sufficient to force the current through the tube.) I now gradually open the gauge until the potential of the inner terminals has risen to a point high enough to allow the spark to pass through the tube, making the yttria phosphorescent.

FIG. 26.—P. = 0·076 mm. = 100·0 M.



P. = 0·000076 mm. = 0·1 M.

FIG. 27.—P. = 0·02 mm. = 26·0 M.



= 6440 = 27,600

The gap is at 7 mm. equal to an E.M.F. of 6,440 volts. I next attach the coil wires to the tube, D, containing the carbon, and the exhaustion in the tubes being the same as before, I repeat the experiment; you now see that the gap has to be opened to 30 mm., equivalent to an E.M.F. of 27,600 volts, before the current will pass through the tube. The fact of whether the vacuum tube contains yttria or carbon makes a difference of 21,160 volts in the E.M.F. required to cause a discharge between the terminals.

One other experiment I would like to show in further illustration of this resistance. The idea suggested itself that possibly differences in the material or conductivity of the particular bulbs might influence the results you have just seen. Here, Fig. 28, is a long cylindrical tube of phosphorescent Bohemian glass containing a pair of terminals, A B; it also contains a shorter cylinder of glass, C C, brightly silvered inside. The internal pressure is 0·00068 mm., or 0·9 M. The silver cylinder is now at one end of the tube out of the way of the terminals, which therefore have phosphorescent glass around them. I turn on the coil and find that the E.M.F. necessary to force the current through, now that the terminals are in a phosphorescent chamber, is 1,380 volts. I slide the cylinder down to the end of the tube so as to enclose the terminals in a metallic silver chamber, and you see the E.M.F. necessary to pass the current rises to 6,440 volts. Metallic silver does not phosphoresce, whilst Bohemian glass phosphoresces very well. It appears that the greater the phosphorescing power of the substance surrounding the poles so much the easier does the induction spark pass. Surround the poles with Bohemian glass or yttria—two phosphorescent non-conductors of electricity—and the induction spark passes easily; immediately I surround the terminals with a non-phosphorescent conductor the current refuses to pass.

WHAT OCCASIONS PHOSPHORESCENCE?

I should like to interest you in a question that has exercised my mind for some time past. What is it that occasions the phosphorescence of yttria and other bodies in vacuo under molecular bombardment?

So far I have found this phosphorescence to be an attribute of non-conductors only. We know that in the act of phosphorescence the molecules of yttria are in a state of intense vibration. Each molecule may be viewed as the radiating centre of the entire bundle of rays, which, when decomposed by the prism, displays a discontinuous spectrum. We may also suppose that the residual atoms of gas charged with negative electricity give off their electricity on coming in collision with a phosphorescent body, and on their return take up a fresh charge.

THE ELECTROLYSIS HYPOTHESIS.

There is a certain amount of evidence in favour of an electrolytic hypothesis of the passage of electricity through rarefied gases. This has been ably advocated by Prof. Schuster in the Bakerian lecture before the Royal Society, March 20th, 1890.*

A molecule of hydrogen gas, for instance, may be made up of one group of atoms of hydrogen having an equivalent of negative electricity inherent in it, and one group of atoms having an equivalent of positive electricity bound up with it. These atoms are also charged with *additional* equivalents of positive or negative electricity, which they carry about as a ship carries its cargo. We are not concerned with the inherent electricity—of which we are ignorant—but with the extra or "cargo" charge. Let us imagine a molecule of hydrogen near the face of the negative pole in a vacuum tube. I turn on the current, and the atoms of the hydrogen molecule are dragged apart. The positive atom is attracted to the negative pole, where the violence of impact, or the discharge of electricity, renders it apparent with evolution of light. The internal luminous layer, which is closely adjacent to the negative electrode, is due, therefore, to the positive atoms rushing to the negative pole, and not, like the glow round the edge of the dark space, to the negative atoms projected from it. The negative atom, on the other hand, is driven violently from the negative pole, in virtue of the mutual repulsion existing between any two bodies similarly electrified, with a velocity varying with the intensity of the electrification, and the degree of the vacuum; the more perfect the vacuum the greater the velocity, the atoms flying outwards in straight lines until they meet with an obstacle. Such an obstacle may be a procession of positively charged atoms from the positive pole. In this case the two kinds of atoms mutually discharge each other's cargoes with a display of light. This phenomenon occurs at the margin of the dark space when the vacuum is only moderate; or the obstacle may be produced by the vacuum being so high that the atoms of gas present are too few to form a continuous procession. (*Why* a high vacuum should be non-conductive does not clearly appear, but the fact itself is beyond doubt. It is probably connected with the inability of electrified atoms to leave the poles.) Or, again, the obstacle may be a phosphorescent body like yttria. In this case the negatively-charged atoms deliver up their charge of electricity to the yttria, which is so constituted—perhaps, after the manner of a Hertz resonator—that its atoms charge and discharge, vibrating about 550 billion times in a second, and producing waves in the ether of the length, approximately, of 5·74 ten millionths of a millimetre, and occasioning in the eye the effect of citron light.

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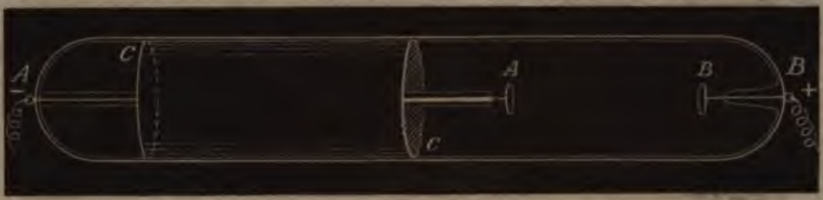
* Royal Society's *Proc.*, xlvii., 526.

Fig. 28.—P. = 0·00068 mm. =0·9 M.



Silver Cylinder off Poles E.M.F. = 1380 Volts.

Silver Cylinder round Poles E.M.F. = 6440 Volts.

We are not under the necessity of supposing that this number of hydrogen atoms are driven against the yttria in the second, although even at a high vacuum there are quite enough atoms left in the bulb to keep up such a supply. All that is needed is that a succession of shocks, not necessarily rhythmical, may strike the yttria at frequencies which will set up such a number of vibrations, just as a series of slow impacts on a gong causes it to emit sound waves of much greater frequency.

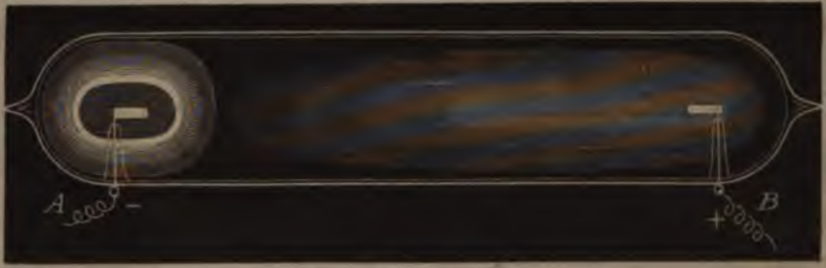


Fig. 29.

In a low vacuum only very few atoms can run the gauntlet among the crowd of inrushing atoms, and those few which succeed in reaching the yttria arrive with much reduced velocity, and so faint is the phosphorescence they set up that it is completely obscured* by the brighter phosphorescence of the residual gas. As the vacuum becomes higher, more and more atoms find their way across, and their speed being at the same time accelerated, the phosphorescence becomes intensified.

At a good vacuum most of the atoms hit the yttria, their velocity is increased, and the rhythmical excitation reaches its maximum.

THE DARK SPACE IN MERCURY VAPOUR.

In applying the electrolytic hypothesis, I have used for illustration's sake the gaseous residue of hydrogen, which is known as a diatomic gas. I have found, however, the phenomena of the dark space, etc., to occur in the vapour of mercury, which is a monatomic gas. This important result induced me to patiently investigate this subject, and the result of one experiment is before you, Fig. 29. The tube is furnished with aluminium terminals, and is so arranged that the induction spark can be kept passing during exhaustion to drive off occluded gases. When at the highest attainable vacuum, the tube is filled with pure mercury by simply raising a reservoir. On applying heat the entire contents of the tube are boiled away and pass down the fall tubes of the pump, exhaustion going on at the same time. When the whole of the mercury has thus been boiled away *in vacuo*, except a little condensed at the upper part of the tube, the results on passing the spark are as follows: when the tube is cold the induction current refuses to pass; on gently heating with a gas-burner the current passes and the dark space is distinctly visible. Continuing the heat so as to volatilise the drops of mercury condensed on the sides, the whole tube becomes filled with a green phosphorescent light, the dark space gets smaller and smaller, and ultimately the negative pole becomes covered with a luminous glow. On allowing the tube to cool the same phenomena ensue in inverse order. The luminous halo expands, showing the dark space between it and the pole, and this dark space gradually grows larger as the tube becomes cooler. The mercury again condenses on the side of the tube, the green phosphorescence grows paler and paler, until at last the induction spark from the large coil refuses to pass.

At first sight this result appears fatal to the electrolytic hypothesis, for if the molecule of mercury contains only one atom how can we talk of its separation into positive and negative atoms by the electric stress? It must be remembered, however, that we are as yet ignorant of the absolute mass of the atom of any element. All that can be said is that a molecule of free hydrogen becomes halved in combining chemically with certain other elements, whilst a molecule of free mercury does not suffer division on yielding any known compound of mercury; the physical atoms in the one behave as two separate groups, and those in the other as one undivided group. It has been agreed by chemists, for simplicity's sake, and for facilitating chemical calculations, to reduce the units to the lowest term consistent with the avoidance of fractions; we therefore say that the atoms in a molecule of free hydrogen act in chemistry as two separate groups, each of a minimum relative weight of 1, whilst those in a molecule of free mercury act as one undivided group of the relative weight 200. But to what number of atoms the 1 and 200 correspond respectively no chemist knows.

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* This faint phosphorescence at a low vacuum can be rendered visible by the electrical phosphorscope described in my lecture at the Royal Institution in 1887.

To show how intimately chemistry and electricity interlock, I may here remark that one of the latest theories in chemistry renders such a division of the molecule into groups of electro-positive and electro-negative atoms necessary for a consistent explanation of the genesis of the elements. This is so important, that I may be excused for digressing a little into this development of theoretical chemistry.

GENESIS OF THE ELEMENTS.

It is now generally acknowledged that there are several ranks in the elemental hierarchy, and that, besides the well-defined groups of chemical elements, there are underlying sub-groups. To these sub-groups has been given the name of meta-elements. The original genesis of atoms assumes the action of two forms of energy working in time and space —one operating uniformly in accordance with a continuous fall of temperature, and the other having periodic cycles of ebb and swell, and intimately connected with the energy of electricity, Fig. 30. The centre of this creative force in its journey through space scattered seeds or sub-atoms that ultimately coalesced into the groupings known as chemical elements. The law which governs the motions of multitudes of men and women in a busy thoroughfare, I have applied to the atoms of gas in a vacuum tube. At this genetic stage the new-born particles vibrating in all directions and with all velocities, the faster moving ones would still overtake the laggards, the slower would obstruct the quicker, and we should have groups formed in different parts of space. The constituents of each group whose form of energy governing atomic weight was not in accord with the mean rate of the bulk of the components of that group would work to the outside, and be thrown off to find other groups with which they were more in harmony. In time a condition of stability would be established, and we should have our present series of chemical elements, each with a definite atomic weight—definite on account of its being the average weight of an enormous number of sub-atoms or meta-elements, each very near to the mean. The atomic weight of mercury, for instance, is called 200, but the atom of mercury, as we know it, is assumed to be made up of an enormous amount of sub-atoms, each of which may vary slightly round the mean number of 200 as a centre.

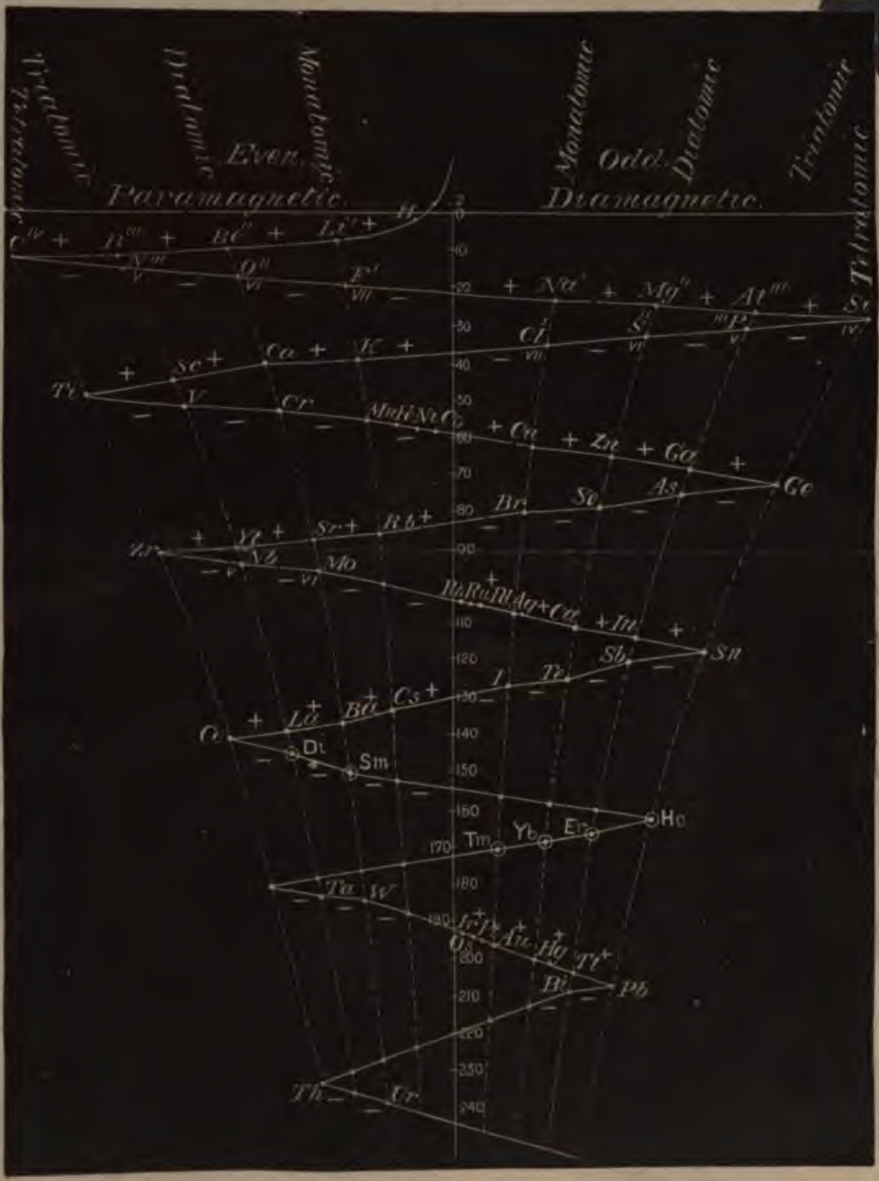

FIG. 30.

We are sometimes asked why, if the elements have been evolved, we never see one of them transformed, or in process of transformation, into another? The question is as futile as the cavil that in the organic world we never see a horse metamorphosed into a cow. Before copper, *e.g.*, can be transmuted into gold, it would have to be carried back to a simpler and more primitive state of matter, and then, so to speak, shunted on to the track which leads to gold.

This atomic scheme postulates a to-and-fro motion of a form of energy governing the electrical state of the atom. It is found that those elements generated as they approach the central position are electro-positive, and those on the retreat from this position are electro-negative. Moreover, the degree of positiveness or negativeness depends on the distance of the element from the central line, hence, calling the atom in the mean position electrically neutral, those sub-atoms which are on one side of the mean will be charged with positive electricity, and those on the other side of the mean position will be charged with negative electricity, the whole atom being neutral.

This is not a mere hypothesis, but may take the rank of a theory. It has been experimentally verified as far as possible with so baffling an enigma. Long-continued research in the laboratory has shown that in matter which has responded to every test of an element, there are minute shades of difference which have admitted of selection and resolution into meta-elements, having exactly the properties required by theory. The earth yttria, which has been of such value in these electrical researches as a test of negatively excited atoms, is of no less interest in chemistry, having been the first body in which the existence of this sub-group of meta-elements was demonstrated.

CONCLUSION.

I frankly admit I have by no means exhausted the subject which daily and nightly fills my thoughts. I have ardently sought for facts on which to base my theory. I have struggled with problems which must be conquered before we can arrive at exact conclusions—conclusions which, so far as inorganic Nature is concerned, can only be reached by the harmonious interfusion—not confusion—of our present twin sciences, electricity and chemistry. Of this interfusion I have just endeavoured to give you a foretaste. In elaborating the higher physics, the study of electrical phenomena must take a large, perhaps the largest, share.

We have invaded regions once unknown, but a formidable amount of hard work remains to be completed. As we proceed we may look to electricity not only to aid, as it already does, our sense of hearing, but to sharpen and develop other powers of perception.

Science has emerged from its childish days. It has shed many delusions and impostures. It has discarded magic, alchemy, and astrology. And certain pseudo-applications of electricity, with which the present Institution is little concerned, in their turn will pass into oblivion.

There is no occasion to be disheartened at the apparent slow pace of elemental discovery. The desponding declare that if Roger Bacon could revisit "the glimpses of the moon" he would shake his head to think we have got no further, that we are still in a haze as to the evolution of atoms. As for myself, I hold the firm conviction that unflagging research will be rewarded by an insight into natural mysteries such as now can scarcely be conceived. Difficulties, said a keen old statesman, are things to be overcome, and to my thinking science should disdain the notion of finality. There is no stopping half way, and we are resistlessly driven to ceaseless enquiry by the spirit "that impels all thinking things, all objects of all thought, and rolls through all things."

CORRESPONDENCE.

COST OF PRODUCING ELECTRICAL ENERGY.

To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Mr. W. P. J. Fawcus, in your issue of the 12th ult., criticises some statements I made in the preceding number of your valuable journal, and I beg indulgence at this late date to again refer to the matters in question. Mr. Fawcus calls into question my remark that the cost of producing electrical energy *averages* 3¾d. per unit in the majority of central stations, and brings figures to prove that this is quite absurd, his figures being obtained from mill installations and others of similar kind. Now, I should like to ask your correspondent if he really considers the two cases parallel instances, remembering the vital point that current must never be off in the case of central station work, and that—take what system you will, A C, with continuous engine power, or B T with the 30 to 40 per cent. loss in the secondary cells—the cost of production, leaving the important one of distribution out of account, the charge on the station per unit will not be much heavier in the case of public supply than in the other one of private installation. Of course if you include distribution, you make a worse case out against the central station. In mentioning such figures as those referred to, I had in mind certain stations to whose data I have access, and on whose results the owners have much reason to congratulate themselves. Surely the basis for comparison, *gas* with electricity, is a good one of 5 cubic feet = 16 c.p., when in this town 4 cubic feet = 16 c.p., and in many cases of large gas consumers an efficiency of five to 10 candles per cubic foot is obtained by use of the regenerative lamps now so common. It must also be remembered that an incandescent can do no more than displace one gas jet, and even then the *effect* in an office or shop in winter is not so good as that formerly obtained with gas. In the case of a small central station I was connected with it was found more economical to use lamps of full candle-power, when, as I stated in my letter, 600 hours was the average life, and I find that consumers reckon in London and here one year as the life of a lamp. How many hours does Mr. Fawcus take this to be?—Yours, etc., CHARLES H. YEAMAN.

Electric Department, Liverpool Corporation,
January 13, 1891.

THE CITY AND SOUTH LONDON RAILWAY.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I shall be obliged if you will kindly insert the enclosed copy of letter which I have addressed to the *Electrician*.—Yours, etc., A. WILLBOND.

[COPY.]

THE CITY AND SOUTH LONDON RAILWAY.

To the Editor of the "ELECTRICIAN.'

Sir,—In the last issue of your journal you state: "During the first fourteen days ending on Saturday last the receipts amounted to £1,947, showing that 233,640 passengers had been carried during that period, or on an average 16,688 per day; that is to say, nearly 40 per cent. more than was estimated by the pessimistic Mr. A. Willbond." This is all very well in its way, and might have passed muster amongst your readers were it not for the extraordinary fact—which seems to have escaped your attention in making up—that you have yourself discounted your own figures by stating that it must "be borne in mind that novelty is only a temporary attraction, and that comfort and regularity will alone secure permanent patronage."

The figures given by me in the *Electrical Review* were based upon permanent traffic, and I have found when travelling on the railway that the actual number of passengers carried was, on several occasions, only a *very small* percentage higher than given in my estimate. "It is, moreover, to be borne in mind that novelty" which "is only a temporary attraction," was at that time still temporarily attracting.

I hope that your readers who have read the two leaderettes in question will find my letter at least a "temporary attraction."—Yours truly,

London, Jan. 13, 1891. A. WILLBOND.

P.S.—When about to post this letter, I find that the official return for last week's traffic give the total receipts as £748. Thus, notwithstanding "temporary attraction," the average number of passengers carried per day was only 12,823, or about 7¼ per cent. more than the number given in my estimate.

UNDERGROUND MAINS.—II.

THE CROMPTON SYSTEM.

(Continued from page 9.)

When the culverts are finished, the next process is the actual drawing in of the mains. These come in copper strip 1in. wide by ⅛in. thick, just as rolled from the mill. They are uncoiled and stamped out straight on the ground by the workmen's feet, and the length between the straining-boxes is measured and cut off. In the first place a cord is passed through the culvert, and usually for this an ingenious and simple method is adopted. At the Kensington station may be seen a curly-haired black dog, a permanent official of the works. This dog, with a cord attached to his collar, is put into the culvert and the top closed in. The men then go to the next box and call the dog, who creeps along, drawing the cord, and so on to the end. The cord is then attached to a chain, and the chain in its turn to the copper strip, which is then drawn in by the men.

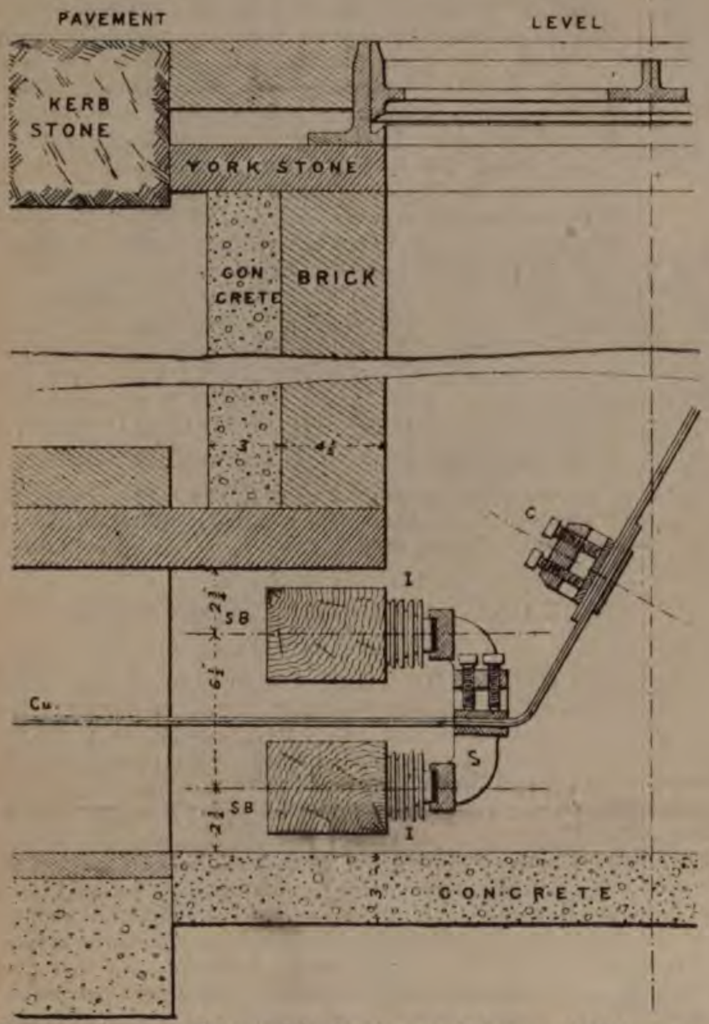

FIG. 8.—Joint from Culvert under Roadway to Culvert under Pavement.

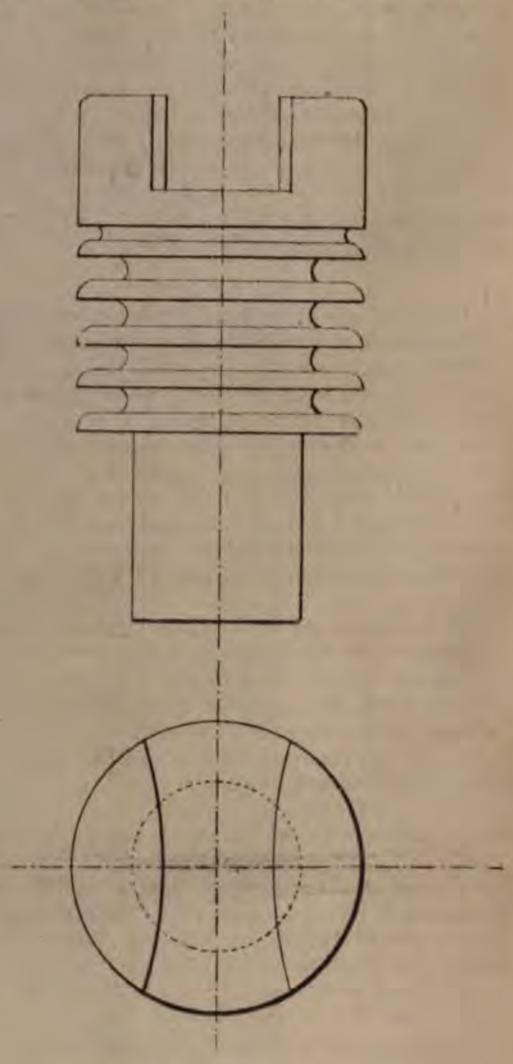

FIG. 11.—Crompton Insulator.

At each insulator box the glass insulators are now pressed into the holes (1¼in. diameter) in the timber baulk. These insulators, I, are of the form shown in the illustration, with five deep rings to give a long length of insulating surface, and thus to guard against leakage by moisture creeping. The insulation is still further increased by each insulator being previously dipped in hot copal varnish. The head of each insulator is slotted out of a width to receive the copper strip. As each strip is drawn past, a man stands at each insulator box along the route and lifts the strip into its position upon the insulator. The three or more strips are thus successively drawn in.

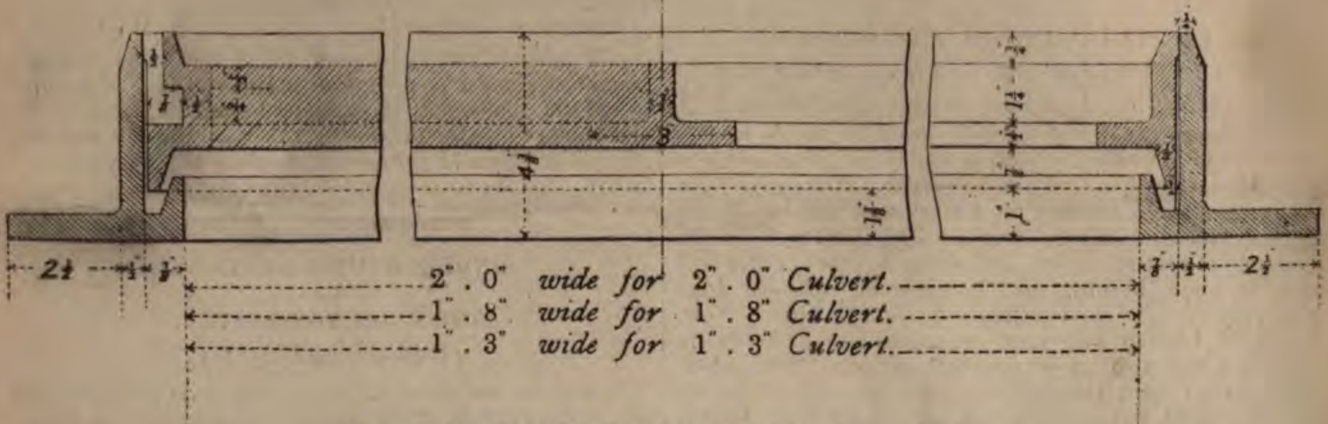
2½
¾
¾
4½
3
1½
1½
1"
2" . 0" wide for 2" . 0" Culvert.
1" . 8" wide for 1" . 8" Culvert.
1" . 3" wide for 1" . 3" Culvert.
2½

FIG. 10.—Box Cover for Straining or Insulator Boxes.—Section.

The copper strips having been passed into the culvert are yet lying along the bottom. They have now to be stretched sufficiently taut to be everywhere in air, except where they touch at the insulating supports. A sag of about 2½in. in the mains is usually allowed between the insulators.

The straining pieces, S, each consist of a bridge or arch made of gunmetal, of the shape shown in the illustrations, and carefully designed to afford the requisite stability, both for resistance to the strain of the copper mains, and for holding these latter absolutely fixed, while at the same time obtaining the highest possible insulation. The insulation is assured by the use of glass insulators with deep grooves, similar to those already mentioned, but more solid and squat to withstand the strain.

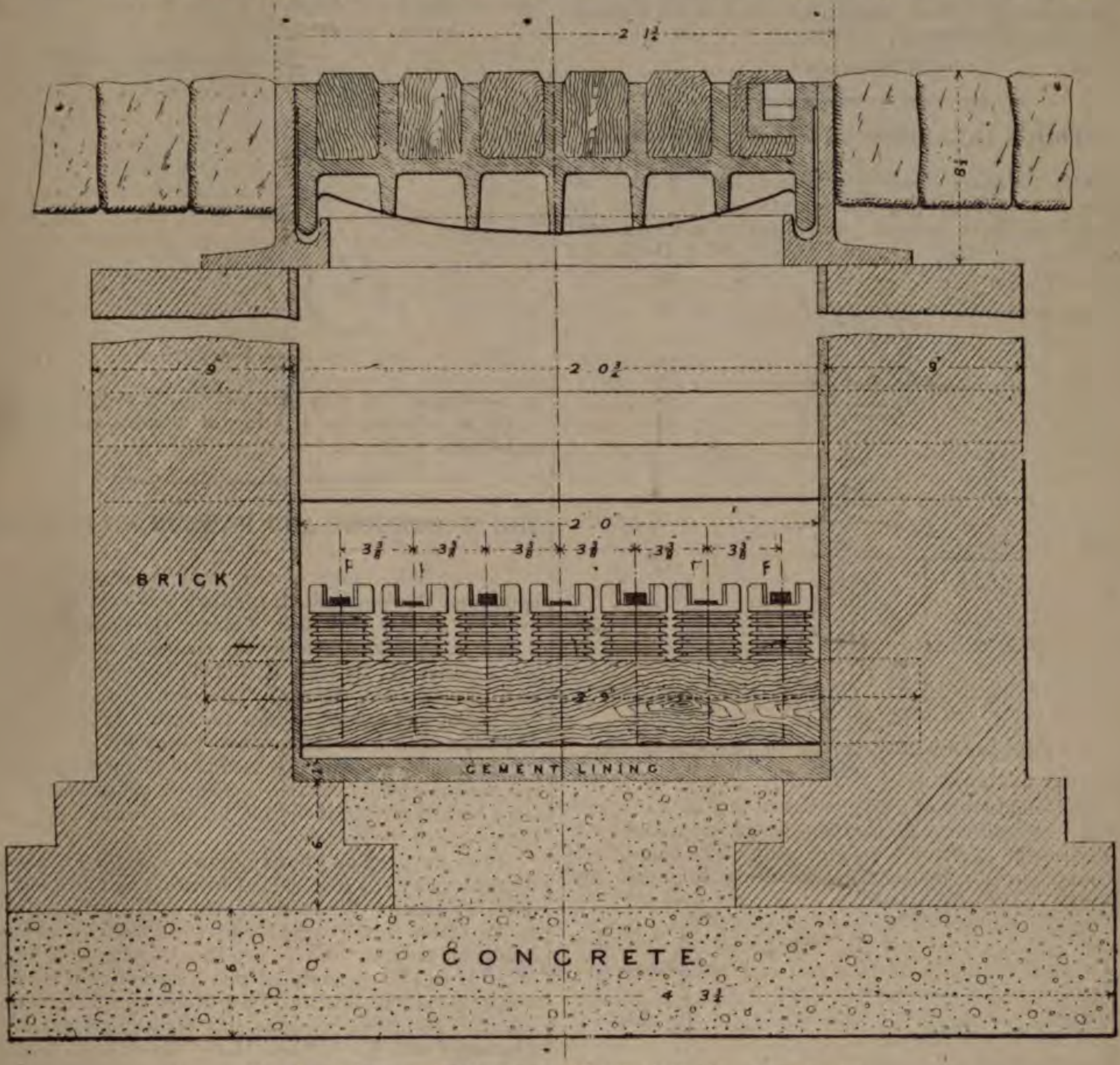

FIG. 9.—Culvert under Roadway with Wood Blocks.—Cross-section.

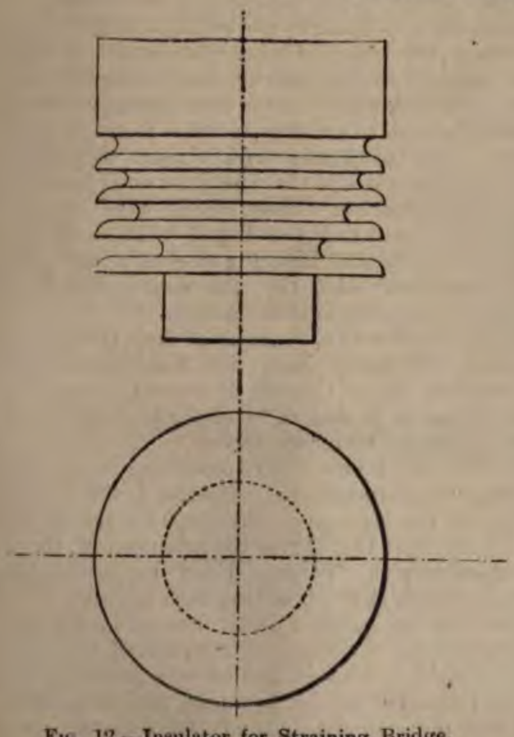

FIG. 12.—Insulator for Straining Bridge.

In placing them into position, a ring or pad of solid indiarubber, R, is first placed against the straining baulk upon these are placed the glass insulators, I I, and then a second pad of solid indiarubber is placed over each insulator, which are thus evenly bedded and enabled to withstand the heavy end strain without the edges chipping off. The gunmetal bridge straining pieces, S, are then placed in position, and the copper main, Cu, is passed through the slot in the centre. It should be noticed that this slot is made with the lower side sloped, or wedge-shaped. A loose piece inside the slot screws down tightly upon the copper main, which is thus slightly bent, and becomes firmly fixed or wedged in position, so that by this simple means the more the strain on the main the tighter it is gripped. The pinching screws are made of aluminium bronze or Delta metal, or in dry situations of steel.

The straining is accomplished in various ways. The most scientific and certain is that often used of a hydraulic jack, made to form a lever to draw the mains up tight. Placed in position at the side of the trench, bedded against the concrete edge, a few strokes of the hydraulic handle tightens up the main, and the pinching screws are then screwed tightly down upon the wedge-piece, W. The straining for shorter lengths is also often done by the simple means of ropes and pulleys, or by a crowbar strained against a baulk, or sometimes by a right or left-handed screw. The means employed are mainly dependent upon the length of the strip, and thus upon the necessity for greater or less force.

When the copper strips are properly tightened from straining-box to straining-box, the ends are overlapped and tightly connected together by a grip box or connecting-box, C, which simply presses the ends of the flat strips firmly together by means of pinching screws. These grip-boxes are large enough to hold four strips, but can be made to hold six strips if necessary.

(*To be continued.*)

OUTDOOR INCANDESCENT LAMP FITTINGS.

High candle-power incandescent lamps are now taking so prominent a position that special fittings for them are becoming largely in demand. We illustrate herewith some types of these fittings made by Messrs. John Davis and Son, Derby.

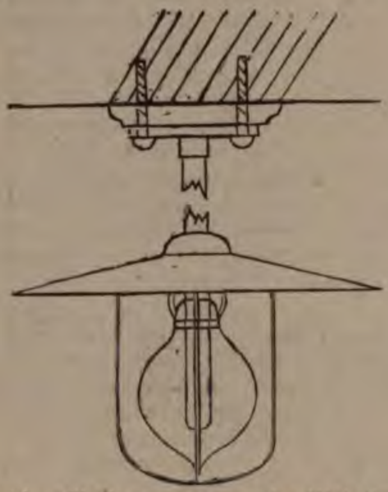

Fig. 1.—Outdoor Shade and Reflector for High Candle-power Lamps.

A very usual style of fitting is shown in Fig. 1. It consists of a wrought-iron bracket and flange, or wrought-iron straight stalk, to fix to a roof or wall. The lamp is contained in a glass shade, with a strong iron case and reflector.

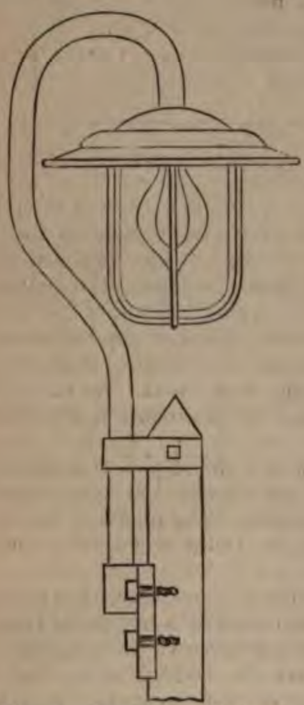

Fig. 2.—Shadowless Fitting.

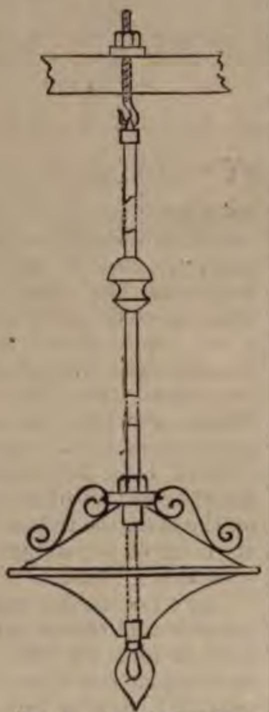

Fig. 4.—Arcade Pendant.

The so-called "shadowless" fitting shown in Fig. 2 is constructed on similar lines, and is designed to fix on the top of a pole, so that the light casts no shadow in any direction. Both of these are found very useful for lighting large spaces.

Another useful form is shown in Fig. 3, consisting of a wrought-iron bracket or straight stalk with a double conical enamelled iron reflector. This pattern is designed for indoor work, where the lamp does not require protection.

Fig. 4 is a fitting of very similar description more elaborately finished. It has a double enamelled reflector and is ornamented with four gilt scrolls and two gilt balls, and is suitable for the lighting of arcades, entrance halls, and similar positions.

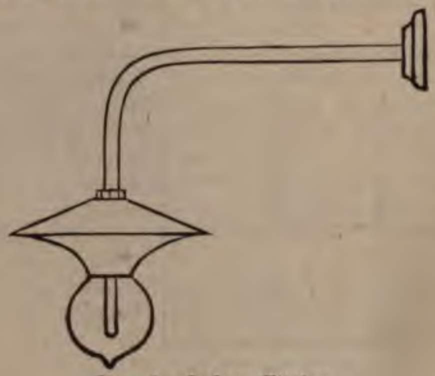

Fig. 3.—Indoor Fitting.

THE WOODHOUSE AND RAWSON STAFF DINNER.

The annual dinner of the head office staff of Woodhouse and Rawson United, Limited, was held on Tuesday evening, at the Guildhall Tavern, Gresham-street. The dinner was presided over by the chairman of the company, Sir Rawson W. Rawson, K.C.M.G., C.B., and there were also present Sir Edward Thornton, Captain Rawson, Dr. Maier, and others, besides the staff. It was extremely successful both from the numbers (some 100 or 120 attending with most evident good feeling of fellowship), also from the announcements of the company's praiseworthy intentions with regard to their staff for the coming year given in the course of the speeches.

When the good and hearty dinner had been disposed of, finished up by the seasonable Christmas pudding, the president, Sir Rawson W. Rawson, paid a very touching tribute to the Queen in the course of his loyal toast by relating the events of kindred Rawsons in the Ashantee and Egyptian War. It will be remembered that a naval officer guided the forces across the desert at Tel-el-Kebir by the light of the stars. This officer, it seems, was Wyatt Rawson, one time lieutenant with his brother, Harry Rawson, on board Her Majesty's private yacht. He led the forces accurately to the spot, joined in the attack and was fatally wounded, dying on his way home to his young wife. The Queen, on decorating the other brother on return of the forces, spoke feelingly to him, making the poor fellow break down utterly and rush away; asked him specially to dinner, and expressed a wish to stand godmother to the orphaned baby girl just born, conjointly with himself as godfather, and with the express desire that the little one's name should be Victoria Alexandrina. These deeds were related both as touchingly illustrating the Royal toast, and as bodying forth the true English honour and enterprise in many fields of the Rawsons, who, the chairman pointed out, were strongly represented in this meeting.

Mr. H. Masterman, manager of their Kidsgrove Works, proposed "The Army, Navy, and Auxiliary Forces," which was responded to by Captain Rawson ("as good an electrician as he is a soldier," said the proposer) and by Mr. Mumford for the merchant service.

Sir Rawson Rawson, in responding to the toast of the evening, "Woodhouse and Rawson United, Limited, the Board, and the Managing Director," on behalf of himself and his son, said that it was the intention of the company to supplement the Pension Fund by establishing some system of profit sharing, so that each member of the company should feel he has a direct interest in the welfare and the profit of the company. The credit of the intention, he said, belonged to his son, and he only claimed for himself and his colleagues on the board an entire approval of the aims and objects, and trusted the scheme would make Woodhouse and Rawson United show an example of a really united body—strong, healthy, and prosperous.

Mr. F. L. Rawson, in responding to the same toast, gave first some very good advice to the young men on the staff upon the subject of good work and promotion. The company now employ, he said, very nearly 1,000 men on their various branches, and indirectly as many more. The chances for men of good habits and ability were therefore considerable. He gave some of the qualities most desirable, ranking reliability above simple ability, pointing out that for managers of a large enterprise to be absolutely sure that what a man undertakes that will he always and certainly do is better than knowing a man to be able to do more and yet not be certain of his doing it. Civility was another great thing to be desired amongst themselves as well as to outsiders, and the man who is easy to get on with is more likely to be himself aided, so likewise the man who is not afraid of giving nothing for nothing—work done apparently for nothing being often paid for again and again—and an amusing picture was drawn of his own younger days when, as a lad, he undertook to design a house for a lady, designs which were not paid for, though many a £10 note has since come from this lady's influence. Before all he would impress them to give good work and good work only; they had not only to think about their present position, but about their position in two or three years time; many of them would be getting married, and even now there seemed quite an epidemic of marriages setting in, of which he was afraid he himself offered a bad example. After this "fatherly" advice he went on to speak of the position of the company. It had been objected that much of their work had been connected with new companies, but it must be recollected that outside people knew very little of the very large amount of actual work that they were also doing, though the staff of course did. They had been passing through a preparatory time in electrical matters, and no one else was making very much out of it, so that they ought to be glad even in this preparatory time the company was paying well. With regard to the Pension Fund full particulars would be given before very long. He was glad to announce that a library for the staff had been started at 34, Cannon-street, and would be well supplied with technical books and newspapers, and arrangements had also been made for a number of lectures to the staff in the evenings. With regard to their already-established system of quarterly bonuses, it had been the habit of the company to offer premiums of two guineas and a guinea for the best invention submitted. This had been originally confined to the works department; they had, however, determined to throw it open to all and to increase it by a five guinea bonus for the best invention, improvement, or suggestion for the business. A committee would be formed to award the premiums once a quarter, and so encourage a constant interest in the firm's work and progress. To better carry out this interest and intercourse between all the branches, it was intended to issue a newspaper, either by themselves, or by arrangement in conjunction with some other journal. With regard to profit-sharing, he did not believe in any scheme of charity, or in helping people, unless in a thorough way, one beneficial to the business as well as to themselves. They hoped to do it in such a way that other firms would also take up the idea, arranging a well-digested scheme so that part of the increase of business should go the employés and part to the firm, and so helping forward the millennium, or whatever else they were going to have in the future.

Mr. L. BROEKMAN, in giving "The General Manager," gave Mr. North great credit for organising ability, both at home and in their foreign extensions, and spoke of the good relations between the manager and the various departments.

Mr. G. NORTH, in responding, gave some fuller particulars of the proposed lectures to the staff. He always advocated a sound mind in a sound body, and in physical ability the company's men in lacrosse, cricket, and football excelled, he thought, all electrical firms. He would like them equally to excel in regard to soundness of minds. When he was asked for situations open (and he was often besieged by numbers of men—young, middle-aged, and sometimes quite old) too often this was the kind of conversation that occurred when he put them through a short examination. He would ask them if they knew shorthand. Well, they *had* learnt it, couldn't write much, but could soon pick it up, no doubt. Languages? They had learnt French at school, didn't remember much of it. Bookkeeping? They didn't know, but thought they could do it—if they were shown the way! Electricity? Yes, they knew something about that; they had used a plate machine at school!' Engineering, mechanics? No, they knew nothing about that. Now, he would ask what on earth were the use of such men as these? The world was full of them. The men the company wanted were those that *could* do something and *did* know something. To help the present staff to better themselves in useful knowledge the company had made arrangements to have a series of lectures, not too technical, upon electrical subjects. The lectures will be free, and will be given at 34, Cannon-street, at half-past six, beginning on Friday, January 16th. The introductory lecture will be given by Mr. Stepney Rawson and the chairman of the company. Sir Rawson Rawson will take the chair on this occasion to give additional *éclat*. It will be illustrated by specimens, diagrams, and a certain number of experiments. The succeeding lectures will be as follows: Mr. Epstein (manager of accumulator department) on secondary batteries; Mr. Nalder on measuring instruments; Mr. Bryan on dynamos and motors; Mr. Stepney Rawson on incandescent lamps; Mr. Thomas (contract department) on arc lamps; Mr. Stuart A. Russell (I.R.G.P.Co.) on testing; Mr. Marsh (supply department) on telephones; and Mr. Reg. J. Jones (contract manager) on installation work. These will be followed by several others on engines, on boilers, and on electric launches. A shorthand class is being conducted by Mr. Harland, also free of charge, and the company intend to make a special condition of engagement on their staff, that everyone shall be able or must learn to write 80 or 100 words a minute.

Mr. W. STEPNEY RAWSON briefly proposed "The Branches," and Mr. H. S. KING, in responding, said it might be truly said that the sun never sets on the Woodhouse and Rawson branches, as they were now established in all parts of Her Majesty's kingdom. It must be remembered that besides their numerous supply branches abroad and in the colonies, they had a very extensive engineering branch in the North, and were now in the proud position of being, he believed, the only electrical company or firm who could carry out an entire installation to light a town without any outside help. Woodhouse and Rawson stood, he said, something like the Westinghouse Company in America, and could supply the whole material for a town, theatre, or private house installation—boilers, engines, dynamos, insulators, wires, everything from their own branches.

Mr. REGINALD J. JONES briefly proposed "The Visitors," coupling with it the name of Dr. Julius Maier, who responded by wishing all the prosperity to the company which they richly deserved

Sir EDWARD THORNTON gallantly proposed an additional toast of "The Ladies," which, amidst much enthusiasm, was responded to by Miss Rawson, who, with Mrs. F. L. Rawson and Miss Fife, had helped in the musical part of the proceedings.

To the toast of "The Chairman," given by Mr. T. D. Dundas, Sir RAWSON RAWSON notified his pleasure in being able to attend at such a full and congenial gathering of the firm's employés, and added, as an incentive to further and willing work, that his own progress in life had been due to his hard and willing work as a simple clerk in the Board of Trade Office having attracted the notice of the Vice-President, so that now after a career of 47 years in the public service he was now, as he hoped they would be in their time, able to enjoy old age in the kindness of friends and associates.

With musical honours a most enjoyable and interesting evening was then brought to a close.

Matlock Bath.—The Local Board have appointed a committee to consider the question of introducing electric lighting into the town. Mr. Geo. Fletcher, electrical engineer to the Midland Railway Company, and Mr. Cameron, of Exeter, have been consulted on the subject. The former estimates the cost of lighting the streets, using water power, at £1,064, and with private lighting added, £2,100.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E

LECTURE IV.

(*Continued from page 48.*)

Again, a suggestion has been made to enclose in an iron jacket the coil employed in this way. Iron-clad solenoids have been employed from time to time. But they do not increase the range of action. What they do is to tend to prevent the falling off of the internal pull at the region within the mouth of the coil. It equalises the internal pull at the expense of all external action. An iron-clad solenoid has practically no attraction at all on anything outside of it, not even on an iron core placed at a distance of half a diameter of the aperture; it is only when the core is inside the tube that the attraction begins, and the magnetising power is practically uniform from end to end. Last year I wished to make use of this property for some experiments on the action of magnetism on light, and for that purpose I had built, by Messrs. Paterson and Cooper, this powerful coil, which is provided with a tubular iron jacket outside, and a thick iron disc perforated by a central hole covering each end. The magnetic circuit around the exterior of the coil is practically completed with soft iron. With this coil, one may take it, there is an absolutely uniform magnetic field from one end of the tube to the other; not falling off the ends, as it would do if the magnetic circuit had simply an air return. The whole of the ampere-turns of exciting power are employed in magnetising the central space, in which therefore the actions are very powerful and uniform. The coil and its uses were described in my lecture last year at the Royal Institution on "Optical Torque."

MODIFICATIONS OF THE COIL AND PLUNGER.

In one variety of the coil and plunger mechanism, a second coil is wound on the plunger. Hjorth used this modification, and the same thing has been employed in several arc lamps. There is a series of drawings upon this wall depicting the mechanism of about a dozen different forms of arc lamp, all made by Messrs. Paterson and Cooper. In one of these there is a plunger with a coil on it drawn into a tubular coil, the current flowing successively through both coils. In another there are two separate coils in separate circuits, one of thin wire and one of thick, one being connected in series with the arc, and one in shunt.

DIFFERENTIAL COIL AND PLUNGER.

There is a third drawing here showing the arrangement, which was originally introduced by Siemens, wherein a plunger is drawn at one end into the coil that is in the main circuit, and at the other end into a coil that is in shunt. That differential arrangement has certain peculiar properties of which I must not now stop to speak in detail. It is obvious that where one core plunges its opposite ends into two coils, the magnetisation will depend on both coils, and the resultant pull will not be simply the difference between the pull of the two coils acting separately. There is, however, another differential arrangement, used in the Brockie-Pell and other arc lamps, in which there are two separate plungers attached to the ends of a see-saw lever. In this case the two magnetising actions are separate. In a third differential arrangement there is but one plunger and one tubular bobbin, upon which are wound the two coils, differentially, so that the action on the plunger is simply due to the difference between the ampere-turns circulating in the two separate wires.

COIL AND PLUNGER COIL

When one abandons iron altogether, and merely uses two tubular coils, one of wide diameter, and another of narrower diameter capable of entering into the former, and passes electric currents through both of them, if the currents are circulating in the same fashion through both of them they will be drawing into one another. This arrangement has also been used in arc lamps. The parallel currents attract one another inversely, not as the square of the distance, but approximately as the distance. This is one of those little details about which it is as well to be clear. About once a year some kind friend from a distance writes to me pointing out a little slip that occurs in my book on electricity, in the passage where I am speaking about the attraction of parallel wires. I have made the terrible blunder of leaving out the word "square"; for I say the attraction varies inversely as the distance, and my readers are kind enough to correct me. Now, when I wrote that passage I considered carefully what I had to write, and the attraction does not vary inversely as the square of the distance, because two parallel wires do not act on one another as two points. They act as two straight lines or two parallel lines, and the attraction between two parallel lines of current, or two parallel lines of magnetism, or two parallel lines of anything else that can attract, will not act inversely as the square, but simply inversely as the distance in between.

INTERMEDIATE FORMS.

Now this property of the coil and plunger of extending the range of action has been adopted in various ways by inventors whose object was to try and make electromagnets with a sort of intermediate range. For certain purposes it is desirable to construct an electromagnet which, while having the powerful pull of the electromagnet, should have over its limited range of action a more equable pull, resembling in this respect the equalising of range of the coil and plunger. Some of these intermediate forms of apparatus are shown in the following diagrams. Here, Fig. 65, is a peculiar form of electromagnet: it combines some of the features of the iron-clad electromagnet with those of the movable plunger; it has a limited range of action, but is of great power over that range, owing to its excellent magnetic circuit. It was invented, in 1870, by Stevens and Hardy, for use in an electric motor for running sewing machines. A very similar form is used in Weston's arc lamp. A form of plunger electromagnet invented by Holroyd Smith in 1877 resembles Fig. 65 inverted; the coil being surrounded by an iron jacket, whilst a plunger, furnished at the top with an iron disc, descends down the central tube to meet the iron at the bottom.

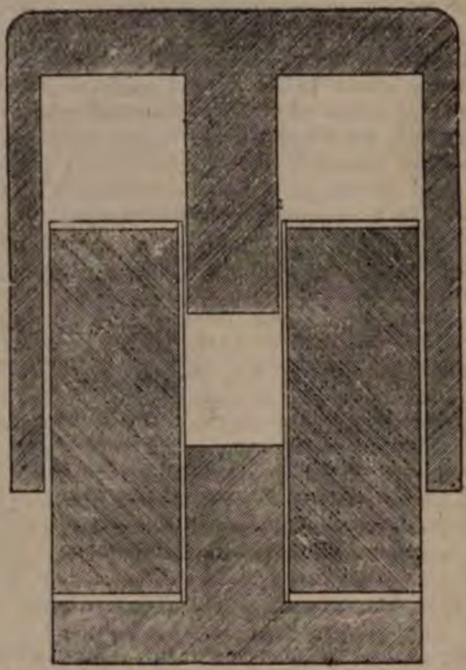

FIG. 65.—Plunger Electromagnet of Stevens and Hardy.

Then there is another variety, of which I was able to show an example last week by the kindness of the Brush Company—namely, the plunger electromagnet employed in the Brush arc lamps. A couple of tubular coils receive each an iron plunger, connected together by a yoke; whilst above, the magnetic circuit is partially completed by the sheet of iron which forms part of the enclosing box. You have here, also, the advantage of a fairly complete magnetic circuit, together with a comparatively long travel of the plunger and coil. It is a fair compromise between the two ways of working. The pull is not, however, in any of these forms equal all along the whole range of travel; it increases as the magnetic circuit becomes more complete.

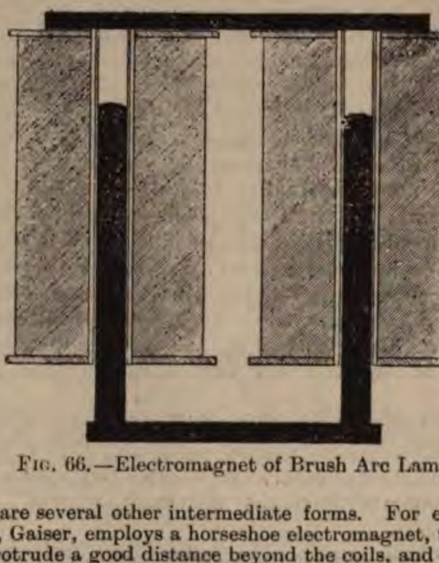

FIG. 66.—Electromagnet of Brush Arc Lamp.

There are several other intermediate forms. For example, one inventor, Gaiser, employs a horseshoe electromagnet, the cores of which protrude a good distance beyond the coils, and for an armature he employs a piece of sheet iron, bent round so as to make at its ends two tubes, which enclose the poles, and are drawn down over them. Contrast with this design one of much earlier date by an engineer, Roloff, who made his electromagnets with iron cores not standing out, but sunk below the level of the ends of the coils, whilst the armature was furnished with little extensions that passed down into these projecting tubular ends of the coils. Some arc lamps have magnets of precisely that form, with a short plunger entering a tubular coil, and met half-way down by a short fixed core inside the tube.

Here, Fig. 67, is one form of tubular iron-clad electromagnet that deserves a little more attention, being the one used by Messrs. Ayrton and Perry in 1882; a coil has an iron jacket round it, and also an annular iron disc across the top, and an annular iron disc across the bottom, there being also a short internal tube of iron extending a little way down from the top, almost meeting another short internal tube of iron coming up from the bottom. The magnetic effect of the enclosed copper coil is concentrated within an extremely short space, between the ends of the internal tubes, where there is a wonderfully strong uniform field. The range of action you can alter just as you please in the construction by shortening or lengthening the internal tubes. An iron rod inserted below is drawn with great power and equality of pull over the range from one end to the other of these internal tubes.

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* Cantor lectures, delivered before the Society of Arts.

ACTION OF MAGNETIC FIELD ON SMALL IRON SPHERE.

In dealing with the action of tubular coils upon iron cores, I showed how, when a very short core is placed in a uniform magnetic field, it is not drawn in either direction. The most extreme case is where a small sphere of soft iron is employed. Such a sphere, if placed in even the most powerful magnetic field, does not tend to move in any direction if the field is truly uniform. If the field is not uniform, then the iron sphere always tends to move from the place where the field is weak to a place where the field is stronger. A ball of bismuth or one of copper tends, on the contrary, to move from a place where the field is weaker. This is the explanation of the actions called "diamagnetic," which were at one time erroneously attributed to a supposed diamagnetic polarity opposite in kind to the ordinary magnetic polarity. A simple way of stating the facts is to say that a small sphere of iron tends to move up the slope of a magnetic field with a force proportional to that slope; whilst (in air) a sphere of bismuth or one of copper tends, with a feeble force, to move down that slope. Any small piece of soft iron—a short cylinder, for example—shows the same kind of behaviour as a small sphere. In some of Ayrton and Perry's coiled-ribbon ampere-meters and voltmeters, and in some of Sir William Thomson's current-meters, this principle is applied.

SECTIONED COILS WITH PLUNGER.

An important suggestion was made by Page, about 1850, when he designed a form of coil and plunger having a travel of indefinitely long range. The coiled tube, instead of consisting merely of one coil, excited simultaneously throughout its whole length by the current, was constructed in a number of separate sections or short tubes, associated together end to end, and furnished with means for turning on the electric current into any of the sections separately. Suppose an iron core to be just entering into any section, the current is turned on in that section, and as the end of the core passes through it the current is then turned on in the section next ahead. In this way an attraction may be kept up along a tube of indefinite length. Page constructed an electric motor on this plan, which was later revived by Du Moncel, and again by Marcel Deprez in his electric "hammer."

WINDING OF TUBULAR COILS AND ELECTROMAGNETS.

The mention of this mode of winding in section leads me to say a few final words about winding in general. All ordinary coils, whether tubular or provided with fixed cores, are wound in layers of alternate right-handed and left-handed spirals. In a preceding lecture I mentioned the mistaken notion, now disproved, that there is any gain in making all the spirals right-handed or all left-handed. For one particular case there is an advantage in winding a coil in sections, that is to say, in placing partitions or *cloisons* at intervals along the bobbin, and winding the wire so as to fill up each of the successive spaces between the partitions before passing on from one space to the next. The case in which this construction is advantageous is the unusual case of coils that are to be used with currents supplied at very high potentials, for when currents are supplied at very high potentials there is a very great tension* exerted on the insulating material, tending to pierce it with a spark. By winding a coil in *cloisons*, however, there is never so great a difference of potentials between the windings on two adjacent layers as there would be if the layers were wound from end to end of the whole length of coil. Consequently, there is never so great a tension on the insulating material between the layers, and a coil so wound is less likely to be injured by the occurrence of a spark.

Another variety of winding has been suggested—namely, to employ in the coils a wire of graduated thickness. It has been shown by Sir William Thomson to be advantageous in the construction of the coils of galvanometers to use for the inner coils of small diameter a thin wire; then, as the diameter of the windings increase, a thicker wire; the thickest wire being used on the outermost layers; the gauge being thus proportioned to the diameter of the windings. But it by no means follows that the plan of using graded wire, which is satisfactory for galvanometer coils, is necessarily good for electromagnets. In designing electromagnets it is necessary to consider the means of getting rid of heat; and it is obvious that the outer layers are those which are in the most favourable position for getting rid of this heat. Experience shows that the under layers of coils of electromagnets always attain a higher temperature than those at the surface. If, therefore, the inner layers were to be wound with finer wire, offering higher resistance, and generating more heat than the outer layers, this tendency to overheating would be still more accentuated. Indeed, it would seem wise rather to reverse the galvanometer plan, and wind electromagnets with wires that are stouter on the inner layers and finer on the outer layers.

Yet another mode of winding is to employ several wires united in parallel, a separate wire being used for each layer, their anterior extremities being all soldered together at one end of the coil, and their posterior extremities being all soldered together at the other. Magnetically, this mode of winding presents not the slightest advantage over winding with a single stout wire of equivalent section. But it has lately been discovered that this mode of winding with multiple wire possesses one incidental advantage—namely, that its use diminishes the tendency to sparking which occurs at break of circuit.

EXTENSION OF RANGE BY OBLIQUE APPROACH.

I now pass to the means which have been suggested for extending the range of motion, or of modifying its amount at different parts of the range, so as to equalise the very unequable pull. There are several such devices, some electrical, others purely mechanical, others electro-mechanical. First, there is an electrical method. André proposed that as soon as the armature has begun to move nearer and comes to the place where it is attracted more strongly, it is automatically to make a contact, which will shunt off part of the current and make the magnetism less powerful. Burnett proposed another means, a number of separate electromagnets acting on one armature, but as the latter approached these electromagnets were one after the other cut out of the circuit. I need not say the advantages of that method are very hypothetical. Then there is another method which has been used many times with very great success—the method of allowing the motion of the armature to occur obliquely, it being mechanically constrained so as to move past instead of towards the pole. When the armature is pulled thus obliquely the pull will be distributed over a definite wider range. Here is a little motor made on that very plan. A number of pieces of iron set on the periphery of a wheel are successively attracted up sideways. An automatic device breaks the circuit as every piece of iron comes near, just at the moment when it gets over the poles, and the current being cut off, it flies on beyond and another piece comes up, it is also attracted in the same way, and then allowed to pass. A large number of toy motors have been made from time to time on this plan. I believe Wheatstone was the first to devise the method of oblique approach about the year 1841. He made many little electromagnetic motors, the armatures of which were in some cases solid rims of iron arranged as a sort of wheel, with two or more zig-zag internal teeth, offering oblique surfaces to the attraction of an electromagnet.

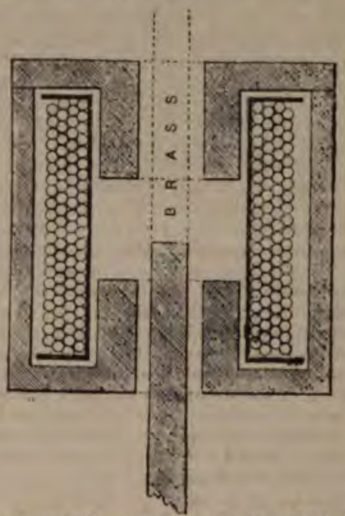

FIG. 67.—Ayrton and Perry's Tubular Iron-clad Electromagnet.

(*To be continued.*)

HOW ELECTRICITY WORKS FOR US.

On Saturday, January 10, a popular lecture was given in the schoolroom of Essex Church, The Mall, Notting Hill Gate, by Mr. Reginald J. Jones, A.M.I.C.E., M.I.E.E., engineer to Messrs. Woodhouse and Rawson United, Limited, on electricity, entitled "How Electricity works for us."

The subject was dealt with firstly as to its historical facts, such as early knowledge respecting the attractive and repulsive powers of amber when rubbed. This section was experimentally illustrated by a very fine plate influence machine of the Wimhurst type. To lead up to the second section, "Telegrams, and how they are sent," facts concerning magnetism were illustrated by some beautiful slides, showing the lines of magnetic force around magnets and wire, the mariner's compass, and construction of electromagnets, etc. Experiments were shown to demonstrate the immense pull or strength that could be got out of electromagnets. Following this some slides were shown illustrating Galvani's experiment with the frog's legs, Volta's pile, modern batteries, and then an experiment showing the deflection of a needle by means of a current, and by reversal of the same, the getting of signals suitable for telegraph work. Various instruments used in telegraphy for the different systems—such as Morse, single-needle, etc.—were exhibited in working order, and the telegraph codes were clearly shown by means of a slide giving the name of the church written in telegraph language. A most striking experiment, showing how thermometer fire-alarms act, was tried by means of a thermometer set to ring a large Jensen bell when a dangerous temperature was reached. A novelty in signalling for war purposes was also shown in the shape of a Scott's signalling lamp, which is probably one of the greatest improvements of modern times for night signalling at sea. The principle of the telephone was then explained by means of slides and instruments. Electricity as a destructive power formed the next section of the lecture. After showing various illustrations explaining submarine mining and torpedo work, an experiment was made by means of which some loose gunpowder was fired. Electric lighting was the next topic, the immortal experiment of Faraday's, upon which the whole of modern electric lighting and transmission of motive power depends—viz., the fact that a current is produced in a coil of wire when a magnet is suddenly put in or drawn out—was shown by means of a diagram and an experiment. The lecture-room being lit by electricity, the lecturer was able to show an arc lamp in operation, in addition to many interesting specimens of incandescent lamps both for mining and surgical operations, and the present position of lighting from central stations and future developments were dwelt upon. To illustrate the production of electric power for lighting purposes, a hand dynamo was shown in operation, and also an ingenious arrangement for automatically detecting and giving warning of any leakage of electricity by means of an apparatus devised by the lecturer, which every half hour, or more frequently if desired, tests any circuit to which it may be connected, and gives warning should there be leakage both by means of the brilliancy of the lamps and by an alarm bell. Medical electricity formed an interesting topic, and a great novelty was exhibited in the shape of an apparatus destined to be better known, called the dental vibrator. By means of this most simple apparatus, teeth can be extracted without the least pain to the patient. The principle of operation is that a rapidly interrupted current is allowed to pass through the body of the patient who grasps a handle in each hand, while a third connection is made to the forceps, so that a shunt of the current passes through the teeth. There is little doubt that this method of extraction will supersede extractions under other anæsthetics. As a suitable conclusion to the lecture, two beautiful illustrations of transmission of power were given in the shape of a motor of the Immisch type driving a fan, and a working model of a crane of novel construction.

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* The tension on the insulating material, tending to pierce it with a spark, is proportional to the square of the difference of potentials (per unit thickness) to which the insulating material is subject. It is incorrect to talk about the tension of the conductor, or about the tension of the current; for the tension or electric stress is always an action affecting the dielectric or insulating material.

In concluding, the lecturer remarked that he had to thank Messrs. Woodhouse and Rawson United, Limited, the Electric Construction Corporation, and the General Electric Traction Company, Dr. Silvanus Thompson, Messrs. Appleton, Drugman, Room, and other friends for their kindness in lending apparatus and slides.

No less than 45 slides were shown by means of an oxy-hydrogen lantern, and the experiments throughout were most successful. The whole of the room was lit by means of E.P.S. cells and incandescent lamps.

COMPANIES' MEETINGS.

EASTERN TELEGRAPH COMPANY.

The thirty-seventh half-yearly ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on Thursday, Sir John Pender, K.C.M.G., chairman, presiding. We give the report of the Directors on the next page.

In the course of his speech the **Chairman** went through the chief items of the report and accounts, congratulating the shareholders upon the success of the Company's operations during the half-year. The expenses in connection with the Paris Telegraph Conference amounted to £981, but they had received full value for their money. The expenses of repairs and renewals of cables amounted to £31,477, against £49,634 for the corresponding period, or a decrease of £18,157. Their cable ships had been employed several times by other companies, and the credits derived thereby had been applied *per contra*. They were able to declare their usual interim dividend of 5 per cent. per annum, and to carry forward £78,195, against £61,151 last year. The Chairman then alluded to the duplicating, triplicating, and even quadrupling of their cables on the Australian route, which had been carried out, and which we referred to in a recent issue—12 had been duplicated, one triplicated, and two quadrupled. This had been done without increasing their capital, at least to any material extent. They had been watching the Dark Continent, in which there was evidence now of renewed activity, and no doubt their traffic would move upwards in sympathy. In conclusion, he moved the adoption of the report and accounts.

This was seconded by the **Marquis of Tweeddale**, and carried unanimously.

The **Marquis of Tweeddale** moved the re-election of Sir John Pender as director in complimentary terms, and **Sir John Pender** moved the re-election of the Marquis of Tweeddale, remarking that he was no fancy director as some people represented, but a man with a good head and great energy. Both these resolutions were duly seconded and carried, as were others re-electing the auditors, Mr. Henry Dever and Messrs. Welton, Jones, and Co., and thanking the Chairman for presiding.

The meeting was fairly well attended, and, as an old shareholder said, was remarkable for its eloquence—the eloquence of silence, which was golden. There were no questions asked.

WOODHOUSE AND RAWSON UNITED.

An extraordinary general meeting of the shareholders of this Company was held on Friday, the 9th inst., at Winchester House, Old Broad-street, E.C., Sir Rawson W. Rawson, C.B., K.C.M.G., in the chair.

The **Secretary** (Mr. Geo. Worrall) having read the notice convening the meeting,

The **Chairman** said ; I am happy, on this occasion, to have the opportunity of repeating the confidence of the Board that the success which has hitherto attended the Company will continue to be maintained. It will be in your recollection that Lord Aberdare stated his opinion to the shareholders very confidently that the capital of the Company was insufficient for the opportunities that it had of realising large profits for excellent and sound undertakings. His colleagues were of the same opinion, and we were prepared at an earlier period than the present to address our shareholders upon that subject if it had not been for the financial crisis which has stopped anything of the kind for some weeks past. There are two objects in the resolutions. The first is to enter into such arrangements as we may think advisable with the liquidators of Woodhouse and Rawson, Limited, for the refunding of the dividend guarantee fund of £75,000 deposited for three years. You will have seen in our balance-sheet for the first year the profits of the year, after paying these rates of dividend to our shareholders, left a surplus of £41,000. That is equal to about a year and a half of our annual payment at these rates to our shareholders. Now, a year and a half has already elapsed of the three years for which the guarantee fund was left in our hands, and it is time that we should consider how that sum is to be repaid. Therefore, we consider it is convenient, when we are asking you to increase our capital for general working purposes, to propose to you, at the same time, an arrangement for repaying that loan upon terms which will be decidedly advantageous to us. We feel confident that the security of our shareholders is perfect as to their 15 per cent. dividend for these three years. One year has elapsed, and we have paid our shoreholders at the rates that we undertook. Another half-year has elapsed also, and our profits have been, I may venture to say, not less than last year. Our expectations of the coming six months are no less favourable. We shall, therefore, at the end of the second year, not only pay our shareholders at the rates of 8 per cent and 15 per cent., but we shall have another surplus to add to the £41,000, wherewith, if necessary, to pay our shareholders for the third year. We are not pledged beyond the third year, but our hopes certainly do extend beyond that period. The second point is that the capital of the Company be increased from the present amount to £550,000. If we have a larger capital we shall be able not only to continue this rate, but to improve it. Our business has largely increased. I have just had put into my hands the earnings of our supply department. The second six months were 50 per cent. over the first six months, and the third six months were 30 per cent. over the second six months. We have to hold in our hands a large and very varied stock of electrical goods to meet the demands of our customers ; and, moreover, we must have a very large outstanding account with several thousand customers. We have already stated to you that we have increased our business by the purchase of one very important and extensive business. We find it necessary that we should manufacture a number of the more important articles required by our customers, so as to be ready to meet their wants without delay, and without the difficulty of procuring them from other people. For that we ask sanction, in order that we may be prepared at the proper time to issue the shares. As regards the debentures, as 6 per cent. is above their proper rate it is our intention to recall them, giving their holders the profit that we promised them at the time of their issue, and issuing probably £200,000 at 5 per cent. That will be a profitable arrangement for the Company ; it will be a profitable arrangement for the shareholder ; it will leave a larger sum available for distribution. As regards the debentures, the holders of them have a largely-increased security. They have the advantage of all the purchases of real property and factories we have made, and in other respects their position will be improved. With regard to our shares, 15 per cent. safely earned, and likely to be continuously earned, ought to place them considerably above par. The delay in the settlement of the affairs of Woodhouse and Rawson, Limited—for, unfortunately, the names are so similar, and now happily settled—the delay in our obtaining our settlement, the last paper for which goes in next week, has combined to lower the value of our shares below their proper figure ; but we feel confident that when our shareholders and the public find that the profits we made last year are not accidental and casual, but will be maintained this year, and have every apparent prospect of continuing during future years, they will have restored confidence in our shares, which will again reach their proper value. We might have called up some of our uncalled capital, but for several reasons this is always undesirable. We have the satisfaction of calling to your notice the success which has attended the Company, both in the matter of the Elmore shares and of the International Okonite shares. Every day confirms the truth of the original statements made with regard to the value of the Elmore process, and the two companies that have been established for foreign countries are only a prelude to more arrangements for the sale of the patent in other countries. The French Company will hold their meeting this afternoon, and I have reason to know that a statement will be laid before the shareholders of that company, which will contain the most satisfactory assurances of the confidence obtained after enquiry by the French members of that Board, that the process is more profitable than has been hitherto held out to the shareholders of the English Company. By arrangements already made they have the expectation of seeing the work on a large scale within the next six months in France, holding out the most satisfactory prospects to the shareholders of that company. The International Okonite have declared an interim dividend of 10 per cent. upon the working of the six months they have been in operation. The certificate of the accountants, Messrs. Price, Waterhouse, and Co., shows that our estimates of earnings for the six months of last year from June and July have been exceeded, and that, it must be borne in mind, has been before the Manchester branch have been able to erect their works, and to commence operations under the Okonite patent in England. Consequently, the success of the International Okonite Company, as far as profits are concerned, is substantiated to the fullest. These are companies in which we have been interested, and that will give you an indication of the class of enterprises that Woodhouse and Rawson United desire to be connected with—no untried schemes, no chance patents, but businesses, patents, and processes that we, with our numerous staff, scientific and financial, and with the variety of factories that we can boast of, are able to thoroughly investigate and test. I move: "That the Directors be authorised to enter into such arrangement as they shall think advisable with the liquidators of Woodhouse and Rawson, Limited, for the immediate or early repayment to such liquidators of the sum of £75,000, or any part thereof, deposited with the Company on the terms that it should be retained till July 1, 1892, as a dividend guarantee fund."

This was seconded by **Sir Edward Thornton.**

In answer to questions, **Mr. F. L. Rawson** (managing director) said the prospects of the business were very good. The Company might have been thought to be speculative in purchasing so many as four businesses in so short a time as 18 months, but what they wanted to do was to put themselves in the position of being able to manufacture and supply creditably to themselves and profitably also to their clients every class of electrical goods. That they were able to do now, with the exception of cable wire, which was a speciality manufactured and sold by itself, and the businesses had turned out very well. In one of them, where they were, perhaps, a little doubtful, they had received an important commission from the Government, which he hoped would turn out very profitably indeed, and result in large future orders. With regard to new companies, as a rule they were connected with a business for one or two years before they brought it out. They gradually built them up, so that they were not really new when they brought them out. With regard to the repayment of the £75,000, they proposed, by their arrangement with the liquidators, to pay this amount in cash or debentures, and they would naturally pay them in the very most advantageous way to the Company. If they gave them the £75,000 in 5 per cent. debentures, it only added £3,750 per annum to their expenditure, which was a very small amount out of a margin of profit £41,000 as last year. With regard to the dividend guarantee fund, the Chairman had told the shareholders that they proposed to pay an interim dividend, as they had already this half-year earned more than enough to pay the dividend for the whole year. They had the £41,000 margin last year; so that really they could not take more than a very small portion out of the dividend guarantee fund in any event. Their profits were now so large, and the increase in the use of electricity was so great, that there was no necessity for going into speculative matters, and he did not think that practically there was a single piece of business into which they had gone that had involved them in a liability of even £10,000. He thought that the manufacturing profits would be considerably larger this year than last. It was rather risky making a guess, but he would not be surprised if they amounted to £10,000 or £12,000 more than last year. The shareholders would be glad to hear that now a very different and better class of business was being offered to them than before.

The resolution was carried unanimously.

The **Chairman** then moved: "That the capital of the Company be increased to £550,000, by the creation of 40,000 new shares of £5 each, of which 20,000 shares shall be preference shares, which shall be entitled to the same preferential dividend and rights, other than the benefit of the dividend guarantee fund, and shall be subject to the same conditions as, and rank for all purposes *pari passu* with, the existing issue of 30,000 preference shares of £5 each of the Company; the remaining 20,000 shares shall be ordinary shares, and shall be entitled to the same dividends and rights, other than the benefit of the dividend guarantee fund, and shall be subject to the same conditions as, and rank for all purposes *pari passu* with, the existing 40,000 ordinary shares of the Company."

This was seconded by **Mr. Philip Rawson** and carried. The usual vote of thanks to the Chairman brought the meeting to a close.

ELMORE'S FRENCH COPPER COMPANY.

The first general meeting of this Company was held on Friday afternoon, 9th inst., at the Cannon-street Hotel, Sir Richard Meade, K.C.S.I. (chairman of the Company) presiding.

The **Chairman** explained that this was only a statutory meeting of the Company, held to fulfil the requirements of the Companies Acts, and not for the transaction of business. They proposed, however, to ask the meeting to sanction certain alterations in the articles of association, of which due intimation was given in the notice convening the meeting, and which were required by the Committee of the Stock Exchange. He stated that the 66,750 shares offered to the public were applied for about four times over, and that a full allotment was made among some 2,000 applicants. The sums due on allotment had, with a small exception, been all paid up, and those still outstanding on the first and final calls were in course of adjustment. The Stock Exchange Committee had granted a settlement for their shares, and, provided this meeting passed the alterations in the articles of association, there would be an official quotation of their shares on the Stock Exchange at a very early date. Steps were also being taken to introduce their shares upon the Paris Bourse. The Directors congratulated the shareholders on having been able to secure the very valuable services of M. Eugene Secrétan, formerly manager of the largest copper manufacturing industry in the world, as the Company's general manager in France. Acting on his recommendation they had decided to establish works in the North of France, and M. Secrétan told them that these would be in operation by 1st July. For this purpose they had applied to the Elmore Foreign Company to lend them £50,000 at 6 per cent. for three years.

M. Secretan made a statement in French, an English version of which was supplied, and said that the new buildings would be handed over to the Company at the end of April, and on the 1st July their works, which were constructed for an output of 370 tons of copper articles per month, would begin work. The sale of these articles was absolutely assured.

In reply to several questions, the **Chairman** said he was informed that the Foreign Elmore Company, which had lent the £50,000 on debentures, would be very glad to issue those debentures to any shareholders of the French Company who were willing to take them up. It had been impossible for the Directors to enter into any part and parcelling in regard to the debentures. The great object they had in view was to secure the possession of a sufficient sum of money to enable them to start, what M. Secrétan assured them was necessary for the success of the Company. They could only do that by accepting the arrangement offered by the Foreign Company to give them the £50,000. A question had been asked about the use of water power at Bellegarde, but he had explained that matter to the meeting. They had secured a site at Bellegarde with water power, but it was impossible for them to commence two manufactories at once, and the weight of evidence in favour of starting in the first instance in the North of France was so conclusive that they were compelled for the present to put Bellegarde aside; but they still retained their interest at Bellegarde, and when the proper time came, and they had money sufficient to try a second factory, they proposed to start there.

Formal resolutions relating to alterations in the articles of the Company required by the Stock Exchange Committee were then passed.

COMPANIES' REPORTS.

EASTERN TELEGRAPH COMPANY.

Report of the Directors, for the half-year ended September 30, 1890, presented to the thirty-seventh half-yearly ordinary general meeting, held at Winchester House, 50, Old Broad-street, E.C., on the 15th inst.

The Directors submit the accounts and balance-sheet for the six months ended September 30, 1890. The revenue for the period amounted to £352,873. 11s. 1d., from which are deducted £91,723 11s. 7d. for the ordinary expenses and £31,477. 17s. 9d. for expenditure relating to repairs and renewals of cables, etc., during the half-year. After providing £5,212. 8s. 2d. for income tax, there remains a balance of £224,459. 13s. 7d., to which is added £2,484. 9s. 7d. brought from the preceding half-year, making a total available balance of £226,944. 3s. 2d. From this balance there have been paid:

	£	s.	d.
Interest on debentures and debenture stock	28,274	13	0
Dividend on preference shares.............. ...	20,474	3	9
Two interim dividends of 2s. 6d. per share each on ordinary shares........................	100,000	0	0
	£148,748	16	9

Leaving a balance of £78,195. 6s. 5d., which is carried forward to the next account. The revenue includes £33,455. 17s. 8d. dividends for the half-year upon the Company's shares in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies. The Directors learn that the negotiations referred to at the last general meeting with certain of the Australasian colonies for effecting a reduction in the tariff will be speedily concluded, and the new rates will be brought into operation at an early date. The Directors have decided in view of a largely-increased traffic with Australasia, to lay a triplicate line from Aden to Bombay, and have entered into a contract with the Telegraph Construction and Maintenance Company for the manufacture and laying of the cable early in the present year. The new Red Sea cable connecting Suez, Perim, and Aden, referred to in the last report, was successfully laid by the contractors in November last. Arrangements have been made to take the direct Suez-Aden 1876 cable into Suakim, thus duplicating the Suakim-Suez section, and adding to the security of submarine telegraph communication with that port. In accordance with the articles of association two of the Directors, Sir John Pender, K.C.M.G., and the Marquis of Tweedale, retire by rotation at this meeting, and, being eligible, offer themselves for re-election. The auditors, Mr. Henry Dever and Messrs. Welton, Jones, and Co., retire, and offer themselves for re-election.

DIRECT UNITED STATES CABLE COMPANY.

The report of the Directors for the six months ended Dec. 31 states that the revenue (subject to revision on decision of the case mentioned below), after deducting out payments, amounted to £43,347, against £42,357 for the corresponding period of 1889. The working and other expenses for the half-year, with income tax, and including the expenses of the New York office entirely borne by this Company, but exclusively of cost of repairs of cable, amounted to £17,556, leaving a balance of £25,791 as the net profit, making with £968 brought forward from the previous half-year a total of £26,759. For the corresponding period of 1889 the working expenses and other payments amounted to £15,509. Interim dividends of 3s. 6d. per share for the quarter ended Sept. 30, and of 3s. 6d. per share for the quarter ended December 31, together amounting to £21,248, have been declared, £5,511 being carried forward. In the case of the Anglo-American Telegraph Company *v.* Compagnie Française du Télégraphe de Paris à New York, the appeal to the Council of State, mentioned in the report to June 30, 1889, is, it is stated, still pending.

CITY NOTES.

City and South London Railway.—The receipts for the week ended January 10 amounted to £748.

Brazilian Submarine Telegraph Company.—The receipts for the week ended January 9 amounted to £5,487.

St. James's and Pall Mall Electric Light Company.—Mr. Egerton H. Clarke has joined the Board of this Company.

Commercial Cable Company.—A telegram from New York says that Mr. Hector De Castro has resigned the vice-presidency of this Company in order to become the secretary of the Inter-Continental Railway Commission.

Western and Brazilian Telegraph Company.—The receipts for the week ended January 9, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,434.

Venezuela Telephone Company.—The Company notifies the payment of an interim dividend at the rate of 3 per cent. per annum. The Stock Exchange have appointed to-day (Friday) a special settling day in the shares 1 to 13,144 and debentures 1 to 572.

Electric Construction Corporation. — The Corporation announces an issue of £100,000 six per cent. first mortgage debentures (part of a total issue of £150,000), redeemable at par on January 15, 1901, or at £106, at the option of the Corporation, on six months' notice, after January 15, 1894. The International Trustee, Assets, and Debenture Corporation, Limited, is authorised to receive subscriptions, at par, for the above-mentioned debentures. This issue is made in consequence of the growth of the business of the Corporation, and for the purpose of extending its operations and repaying a banker's advance of £30,000 (secured by temporary debentures), which has enabled the Corporation to complete and equip its new works at Bushbury, Wolverhampton.

PROVISIONAL PATENTS, 1891.

JANUARY 5.

176. **Improvements in electric dynamos and motors.** William Terrell Garnett, Sunbridge-chambers, Bradford.
184. **Improvements in armatures of dynamo machines.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.
185. **Improvements in dynamo machines.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.
200. **Improvements in or connected with electric arc lamps.** Lucien Brianne, 4, South-street, Finsbury, London.

JANUARY 6.

223. **Improvements in primary electrical batteries.** William Henry Todd, 1, St. James's-square, Manchester.
230. **Improved mechanism for actuating clocks by electricity.** Frank Schwartz, Monument-chambers, King William-street, London.
244. **A wire guard for electric lamps.** Charles Harrison, 136, Kentish Town-road, London.
248. **Improvements in mechanism for transferring electric car batteries.** Frederick Gleason Corning, 76, Chancery-lane, London. (Date applied for under Patents Act, 1883, Sec. 103, 9th June, 1890, being date of application in United States.) (Complete specification.)
258. **Improvements in electric arc lamps.** Albert Gay and Robert Hammond, 46, Lincoln's-inn-fields, London.
271. **Improvements connected with electric arc lamps.** Albert Schoenerstedt, 166, Fleet-street, London.
284. **A new or improved telephone transmitter.** Erhard Ludwig Mayer, Norfolk House, Norfolk-street, London.
285. **A new or improved method of telephonic transmission and apparatus therefor.** Erhard Ludwig Mayer, Norfolk House, Norfolk-street, London.

JANUARY 7.

303. **Improvements in electric railway systems.** Charles K. Harding, 46, Lincoln's-inn-fields, London. (Date applied for under Patents Act 1883, Sec. 103, 9th June, 1890, being date of application in United States.) (Complete specification.)
309. **Obtaining electricity by waste water power.** Nicholas Parascho and Constantine Constantinides, 5, Herne-road, Chiswick.

JANUARY 8.

361. **Improvements in dynamo-electric machines.** Francis William Webb and Arthur Moore Thompson, Holly Bank, Crewe.
389. **Improvements in electricity meters.** Francis Teague, 433, Strand, London.
394. **Improvements in electric measuring instruments.** Walter Thomas Goolden and Sydney Evershed, Woodfield Works, Harrow-road, London.

JANUARY 9.

439. **Improvements in torpedoes propelled and steered by electricity.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Winfield Scott Sims, United States).

JANUARY 10.

475. **The absolute silence of telephone, telegraph, and other wires, whether attached to chimneys, buildings, iron standards on roofs, or wooden poles placed in any position.** Alfred Evan David Walters, 12, Hudson-road, Southsea.
476. **Wire coupling for electrical conductors.** William Edgar Banta, 62, St. Vincent-street, Glasgow. (Date applied for under Patents Act, 1883, Sec. 103, 11th June, 1890, being date of application in United States.) (Complete specification.)
490. **Improvements in construction of electric batteries for application to the firing of firearms and other explosive appliances.** Sally Adolf Rosenthal and William Smethurst, 1, Gresham-buildings, London.
492. **A jointed bracket for electric lamps.** Robert Williamson, 54, Fleet-street, London.
508. **An improved underground electric conduit.** William Henry Munns, 106, Victoria-chambers, Chancery-lane, London. (Homer Young, United States.)
536. **Improvements in dynamo-electric generators and motors.** Claude William Atkinson and Llewelyn Birchall Atkinson, 1, Queen Victoria-street, London. (Complete specification).

SPECIFICATIONS PUBLISHED.

1888.

12594. **Phonographs.** Gourad (Edison). 11d. (Second edition.)

1889.

1101. **Electric conductors.** Lowrie and Hall. 8d. (Second edition.)

1890.

2241. **Electric vote indicator, etc.** Robinson. 8d.
2527. **Electric arc lamps.** Cornwell. 8d.
3163. **Electric switches.** Alexander. 6d.
7186. **Welding metals electrically.** Thompson (Coffin). 6d.
9668. **Elevating, etc., electric lights.** Habendahl and others. 6d.
13009. **Printing telegraphs.** Odell. 1s. 1d.
13362. **Automatic telegraphs.** Edwards (Cassalette and another. 1s. 6d.
14634. **Electric light signalling.** Inglefield. 6d.
15043. **Electric heating apparatus.** Lake (Abshagen). 8d.
15084. **Electric railway conduits.** Van Depoele. 8d.
16346. **Distributing electricity by storage batteries.** Currie. 8d.
18292. **Electrical switches.** Drake and Gorham. 6d.
18576. **Controlling electric currents.** Nevile. 8d.
18625. **Electric welding, etc.** Lake (Lemp). 8d.
8631. **Welding metals by electricity.** Lake (Thompson). 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	2
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	7½

NOTES.

The Dover-Calais Cable broke on the 16th inst.

Prof. Ewing.—It is stated that a Cambridge University honorary degree will be conferred upon Prof. Ewing.

Hanley.—The Town Council have approved the draft of their provisional order and decided to deposit £50 with the Board of Trade.

Ice Carnival.—At Cambridge last week ice carnivals were held on the flooded and frozen meadows under the brilliant rays of the electric light.

Telegraph Extension in Africa.—The British East Africa Company have opened a coast telegraph line between Mombassa and Melindi, 70 miles north.

South American Cables.—The s.s. "Silvertown" completed, on January 15th, the Chorillos-Yquique section of the new Central and South American Co.'s cables between Chorillos, Yquique, and Valparaiso.

Lowestoft.—The Town Council are thinking of going in for an order. The gas supply is not in their hands, and the company won't reduce the price when asked to. Hence the raising up of the electric light bogey.

Eastbourne. —Compton-place House, Eastbourne, is being prepared as a residence for Lord Hartington. Extensive alterations have been made in the house and grounds, and the mansion and stables will be lighted electrically.

The Rubber Syndicate.—A telegram from New York dated Saturday, says, quoting news received from Para, that the subscription to the new Rubber Syndicate on the first day was £2,000,000. The whole amount will be called for.

Royal Society.—Last evening the following papers were to be read before the society—viz., H. Wilde, F.R.S., on the "Unsymmetrical Distribution of Terrestrial Magnetism," and T. Andrews, F.R.S., the "Passive State of Iron and Steel," part two.

Camberwell.—The Vestry have given their consent to the application of the Camberwell and Islington Electric Light and Power Supply Company for obtaining an order to supply electricity in East Dulwich, Peckham, Nunhead, Camberwell, Denmark Hill, and old Kent-road.

Sunderland.—A special meeting of the Town Council has been summoned for February 16, to consider the advisability of making application to the Board of Trade for a provisional order under the Electric Lighting Acts, 1882 and 1888, for the supply of electricity within the borough.

Naval Ball at Plymouth.—The barracks at Keyham, where the naval ball is to be held to-night, have been lighted electrically. The current is to be supplied from the cruiser "Racoon," which lies at anchor off the barracks. No less than 1,600 yards of cable have been used for conveying the current from the ship to the shore.

Overhead Wires. —The Newington Vestry have decided to convey to the Local Government Board their opinion that the control of all subways and overhead wires should be placed under the control of the London County Council, and not under the district councils, as suggested in the memorial from the Strand District Board.

New French Cables.—Early this year the Société Française des Télégraphes Sous Marins will lay two cables, from Paramaribo to Cayenne, and from Cayenne to Vizen (Para). These cables connect French Guiana and the general international telegraphic system, and will put Brazil and the other countries of Southern America in direct communication with North America.

Hebden Bridge (Lancs.).—The telephone has been adopted as a means of communication between the central and branch co-operative stores at Hebden Bridge. The board of managers of the local co-operative society have just decided to have their several country branches connected with the central premises, and they have accepted the tender of Mr. R. S. Blackburn, electrician, of that town, who has the work in hand.

Paris-London Telephone Line.—It is stated that the telephone service between Paris and London will not be inaugurated until March 1. The cable will be immersed on February 15, and the official trials will last until the end of the month. The tariff has been definitely fixed at 10f. for three minutes' use of the telephone. It is also stated that M. Carnot and the Queen will formally inaugurate the cable by exchanging greetings over the line.

Private Installation.—The Marquis of Londonderry has decided to light Wynyard, his residence in the county of Durham. No less than 750 incandescent lamps will be employed, and the plant will comprise steam engines and dynamos of some 100 h.p. in the aggregate. The contract for the installation has been placed with Messrs. Drake and Gorham, who will carry out the work under the superintendence of Mr. A. A. Campbell Swinton as consulting engineer.

More Direct Wires.—At the last meeting of the Plymouth County Council, the town clerk announced that the Mayor and himself had had an interview with the head of the telegraph department at the General Post Office, and presented the memorial from the Council in support of the provision of a direct telegraph wire between Devonport and London. The official said the matter had already been enquired into, but the memorial would receive attention.

A Submarine Cannon.—News from Rome mentions that experiments have been made in Lake Como with a submarine cannon invented by Signor Toselli, which can be fired at any depth. The odd thing about this gun is that it can be discharged without the use of electricity. Hitherto none of these submarine wonders have been perfect unless electricity played some part in their working. We are afraid Signor Toselli has omitted a most attractive and gold-alluring agent from his subaqueous peace preserver.

Private Bills.—Among the Bills that have passed the examiners at the House of Commons are the Overhead Wires Bill of the London County Council, and a Bill by the Gas Light and Coke Company to remove doubts as to their power to enter premises of the consumer to disconnect the gas, and empowering them, after giving 24 hours' notice, to enter the premises of any consumer between the hours of nine and four if he has ceased to take or require a supply of gas, or has neglected to pay the rent due to the company, and to disconnect the service pipe.

Electric Railway for New York.—A telegram from New York, dated 20th inst., says: "A company has been formed here, with 3,000,000dols. capital, to carry out a scheme for connecting New York City, Brooklyn, Jersey City, and Harlem by a tunnel and a service of electric trains. Mr. Austin Corbin and other very wealthy financiers are promoting the scheme. It is intended to be a practical solution of the rapid transit problem, and will extend both sides of New York City by connecting Brooklyn and Jersey City near Castle Garden.'

Prof. Tyndall.—After the disquieting paragraphs with reference to Prof. Tyndall's health that have been appearing in the daily press, we are very glad to see a letter from his own pen, dated the 20th inst., in which he says: "Since my return from Switzerland, in October, I have been much knocked about by sleeplessness, added to which, later on, I have had to endure the tortures associated with severe inflammation of the veins of one leg. But the worst is now past. I am under the care of a sagacious London physician, who on visiting me yesterday reported most favourably on my progress."

School of Electrical Engineering.—We are informed that Mr. Leon Drugman, M.Inst.E.E., manager of this school, has obtained the consent of Sir Samuel Canning, M.I.C.E., M.I.E.E., Messrs. P. Herbert Carpenter, D.Sc.F.R.S., Gisbert Kapp, M.I.C.E., M.I.E.E., and Prof. Alex. B. W. Kennedy, F.R.S., vice-president Inst.M.E., to form a permanent "consulting committee," who will have the control of the teaching of the school. After having had to record a month ago the untimely death of Mr. W. Lant Carpenter, we can now congratulate the school upon having secured the valuable co-operation of professional men of such high standing.

Dorking.—At the last meeting of the Local Board Mr. Clift, chairman of the Electric Lighting Committee, stated that the committee had not yet prepared a report to present to the Board. They had visited several towns, and there were others they contemplated visiting, and they would reserve their report until they had been to these places. Some members of the committee had been to Woking, and met with a courteous reception from the manager of the works. The surveyor had been to Godalming, and the committee to Chelmsford, where they met with a pleasant reception. They saw the whole of the works, and received such information as it was possible to get.

The London Eiffel Tower.—The report of the Metropolitan Railway contains the following paragraph relating to the proposed tower at Wembley Park: "The Tower Company, Limited, having secured the Wembley Park Estate, situate between Neasden and Harrow, and about six miles from Baker-street, entered into an obligation with this company to offer £60,000 of their share capital to Metropolitan proprietors, and to set aside an additional £40,000 of their capital to meet any further applications. The whole of the £60,000 has been taken up, and applications for additional shares have been received. The station stipulated to be erected at Wembley Park is in course of construction, and will be completed very shortly."

Increase in Telegraph Business.—The enormous increase in the telegraph business within the bounds of the metropolis has necessitated a large increase in the staff outside the Central Telegraph Office. Various offices are finding it impossible to cope with the amount of work now falling to their share, and appointments have been offered to many candidates who were unsuccessful in the last examination for male telegraph learnerships. An intimation has been given that in all future examinations only the highest successful candidates will be trained for the central office, the remainder being drafted to offices within the London postal district, in which the pay is the same, although the prospects of promotion are more remote.

Exhibition at Palermo.—It is proposed to hold a national exhibition in Palermo from November, 1891, to May, 1892. There will be an international section for engines and machinery relating to small industries such as are carried on in small workshops or dwellings. The demand for engines and machines that can be introduced into such places with safety is very great and increasing in Italy, and it is reasonably expected that manufacturers of this class of goods will receive material advantage by taking part in the exhibition. The executive committee has already succeeded in obtaining a considerable reduction in the freights for exhibits, and further negotiations are still going on in this direction. Information can be obtained at the Italian Chamber of Commerce, 4, St. Mary Axe, E.C.

Bradford (Yorks.).—At the last meeting of the Corporation it appeared from the minutes of the Gas and Electricity Supply Committee that the gas works are to be enlarged. As regards electric light work, Mr. Cowgill said he had heard that all street work in connection with electric lighting was done by the Corporation's workmen, and was superintended by a Corporation foreman. He therefore desired to know whether Mr. Shoolbred obtained a commission upon the cost of the works that were executed in this way. Alderman Priestman said Mr. Shoolbred had been paid ever since the electric lighting works commenced a sum of 3 per cent. upon the outlay. Whether this percentage was allowed upon expenditure in the streets he could not at the moment say.

Destroying Microbes.—Several attempts have been made to destroy microbes by the electric current, but not with much success, says the *Globe*. Schiel tried it in 1875, and finding that the bacteria ceased to move under the action of the current, too hastily concluded that they were dead. Cohn and Bonno-Mendelsohnn showed that they were not dead, but only sterile. They succeeded, however, in killing the microbe by long-continued currents in the nutritive solution. Three Marie-Davey cells applied for 24 hours were found to destroy the bacteria, but a doubt remained as to whether they were killed by the electricity or poisoned by the electrolytic changes produced in the solution by the current. Recent experiments of Apostoli and Laguerriere, and also by Prochownick and Spoeth have not resolved this doubt.

The Barking Traction Station.—On Monday, the 19th inst., the St. Luke's Vestry, accompanied by Mr. M. C. Meaby, the surveyor to the Vestry, and Mr. J. W. Ransom, the engineer of the North Metropolitan Tramways Company, visited the General Electric Power and Traction Company's electric cars and installation on the Barking-road section of the North Metropolitan Tramways Company's system. Having made a minute inspection of the many points of interest in the working of the cars, the Vestry expressed themselves as greatly pleased at all they had seen. The tramway company having signified their intention to run electric cars from Stamford-hill to Moorgate-street, and as this Vestry controls that portion of the route which includes Moorgate-street, their inspection was on that account most exhaustive.

The Woodward Storage Battery.—As we believe we were the first technical journal in this country who called attention to the Woodward storage system, we have naturally watched its progress with interest in the States. Dr. Woodward has recently secured patents in this country for a new form of cell which opens up an entirely new departure from the grid form of plate hitherto used. The new type is in the shape of a perforated cylinder, and batteries are being specially manufactured with a capacity up to 2,000 ampere-hours output. We learn that Dr. Woodward has arrived in this country with the intention of establishing works in England to fully develop the Woodward system in Europe. We are promised a full description of the method of manufacture of this the new type cell, which we shall describe in an early issue.

London Chamber of Commerce.—A meeting of the Electrical and Allied Trades' Section Committee will be held on Monday next at 4 p.m. The following is the agenda: 1. Board of Trade provisional orders in regard to telephones, suggested modifications in. 2. Board of Trade rules and regulations *re* overhead wires, report of sub-committee. 3. Board of Trade forms of accounts, report of sub-committee on. 4. Board of Trade Electrical Standards Committee, correspondence in connection with. 5. Proposed exhibition in London of electrical appliances, letter from Mr. Seymour Wade. 6. St. Pancras Electrical Exhibition, letter from Messrs. W. T. Goolden and Co. 7. Automatic electric railway signalling, letter from Mr. Martin Perls proposing address on "Is railway travelling safe as managed at present?" 8. Other matters.

Our Warships' Compasses.—A writer signing himself "R.N., Retired," says, in a recent issue of the *Western Morning News*: "I have just been reading an account of the narrow escape of the 'Serapis' off Ushant. Surely there must be something to account for her getting so much out of her course besides current. My belief is that the fault is to be found in the compasses supplied to our men-of-war. They are far too small to steer by. Going on board a man-of-war from a merchant steamer, they always look to me ridiculous. How is it that all our large ocean liners and most merchant steamers have adopted large steering compasses? Why, because they have found them absolutely necessary if they want to make their course. Nearly all of them now steer to degrees, and not quarter-points, which is found not to be correct enough in a long day's run. Steering to a degree is impossible with the small compasses used in our men-of-war. I know that small compasses are supposed to be the best in theory, but then theory and practice in all cases don't fit in, and this seems to me to be one of them."

Royal Meteorological Society.—The annual meeting of this society was held on Wednesday, the 21st inst., at the Institution of Civil Engineers, 25, Great George-street, Westminster, Mr. W. H. Dines, B.A., vice-president, in the chair. The report of the council stated that the progress of the society during the past year had been of a satisfactory character. Among the investigations carried on by the society are the following: The organisation of a large number of meteorological stations, the observations from which are examined and reduced by the staff, and printed in the *Meteorological Record*; the regular inspection of these stations by the assistant secretary; the collection and discussion of phenological observations; and an enquiry into the thunderstorms of 1888 and 1889. An exhibition of instruments is held annually in March. During the year a complete catalogue of the library, extending to 222 pages, has been compiled and published. The library has so much overgrown the present limited accommodation, that the council have been obliged to consider the question of obtaining more commodious rooms, and have consequently inaugurated a "New Premises Fund," which is being well supported by the Fellows.

Electro-Harmonic Society.—A smoking concert will be held on Friday next at the St. James's Hall Restaurant (Banquet-room), Regent-street, W., at 8 o'clock. The following is the programme:—Part 1: Glee, Messrs. J. Brown, A. Thompson, W. G. Forington and R. Hilton; new song, "Thoughts and Tears" (Hope Temple), Mr. W. G. Forington; pianoforte solo, "Prelude and Fugue in G minor" (Bach-Liszt), Mr. Alfred Izard; song, "The Banks of the Bann" (E. German), Mr. Arthur Thompson; glee, Messrs. J Brown, A. Thompson, W. G. Forington, and R. Hilton; violoncello solo, "Second Morceau de Salon" (Albert), Monsieur B. Albert; song, "Hybrias, the Cretan" (J. W. Elliott), Mr. Robert Hilton; humorous sketch, Mr. James Kift. Part II.: Glee, Messrs. J. Brown, A. Thompson, W. G. Forington, and R. Hilton; song, "Weep no more, thou sorry boy" (Hatton), Mr. W. G. Forington; serenade, "Neapolitan song" (Tosti), Mr. Arthur Thompson; violoncello solos (a) "Marche Villageoise" (Albert), (b) "Etude Caprice" (Goltermann), Monsieur B. Albert; glee, Messrs. J. Brown, A. Thompson, W. G. Forington, and R. Hilton; old song, "Now Phœbus" (Dr. Arne), Mr. Robert Hilton; humorous sketch, Mr. J. Kift.

Music by Telephone.—At the Midland Institute *conversazione* last week, the National Telephone Company fitted up four rooms in the institute building, connected with London (125 miles), Liverpool (140 miles), Manchester (93 miles), and Bradford (125 miles). The rooms were each fitted to accommodate 32 listeners, so that 128 people at one time could enjoy musical performances going on in four far distant towns. Over the London wire came first, between seven o'clock and half-past eight, the strains of a concert. Then the wire was turned on to the Savoy Theatre to hear "The Gondoliers," with such success that everyone was very loth to withdraw from the telephone until the curtain fell in London. In an adjoining room could be heard from Manchester, now "Aladdin" from the Theatre Royal, now "Bo Peep" from the Prince's. From Bradford came the sounds of a concert, while in the next room the telephones recorded the performance at the Court and Prince of Wales's Theatres, Liverpool. The amusement was not confined to the listeners, for by-standers derived considerable fun from the wagging of heads, beating of time, and other (practically) unconscious demonstrations of approval of the various performances by those in possession of the telephones.

Stafford.—The Electric Lighting Committee of the Town Council have sent out circulars to likely consumers within their area, requesting them to state, before the 31st inst., if they wish to have a supply of electricity for lighting purposes, the kind of premises to be served, the number of lights, and whether the supply is to be under contract or by measurement. The committee have fixed the price at 7d. per Board of Trade unit if the supply is by meter, or 40s. per annum for each 16-c.p. incandescent lamp if by contract, which the committee now recommend, except in special cases where a large number of lights are required. The committee put the equivalent price of gas at 5s. 10d. per 1,000 cubic feet. It is estimated that the cost of supplying and fixing the necessary inside wiring, internal fittings, and lamps will be about £1. 5s. per light; but the figure will vary according to the number and decorative nature of the fittings adopted. This expense the consumer will be required to bear. The service supply on public ground will, as in the case of gas, be put in free; but where consumers prefer to pay by measurement, they will be required to provide their own meter. The electric lighting service is under the direction of Mr. J. Ferguson Bell, the gas engineer of the Corporation.

German Telegraph Tariffs.—On the advice of Herr von Stephan, the Imperial Government has again reduced the tariff for telegrams within Germany, this time from six to five pfennigs a word, with a minimum charge of 50 pfennigs, or 6d., for any message, however brief. Herr von Stephan declares, however, that he sees no good and sufficient reason to yield to the demand of 234 newspapers which have petitioned for a reduced tariff for Press telegrams. These newspapers, he says, have already enjoyed advantages enough in the lowness of the rates for their postal transmission, as well as in the comparative cheapness of the wires of which they might have the special use overnight. Of over 14 million telegrams that were last year sent and delivered within the Empire only 1·29 per cent. were Press messages, representing a revenue to the State of about 153,000 marks, or £7,600. If the Press are granted a special price for telegrams, charitable societies, universities, etc., will be sure to follow suit with similar requests for exceptional treatment which can never be accorded. The present tariff, the German Postmaster-General thinks, is not too high, as witness the many unnecessary telegrams which the newspapers print. This is very unkind of Herr von Stephan, but it is also very true.

Institution of Electrical Engineers.—On Thursday week the hall of the Institution of Civil Engineers was crammed with electrical men—and women—anxious to hear what Mr. Wm. Crookes had to say on "Electricity in Transitu: from Plenum to Vacuum," which was the subject of his presidential address. Prior to the address a hearty vote of thanks was accorded to Dr. John Hopkinson, last year's president, on the motion of Mr. Alexander Siemens, seconded by Mr. Kapp, after which Mr. Crookes took possession of the vacant chair amid enthusiastic manifestations of approval. The address, which we gave in full last week, was listened to with the deepest attention from first to last, though to do so necessitated a very considerable exercise of mental power over some two hours of time. The experiments demonstrating the theories expounded were very beautiful, and with but one or two exceptions (unavoidable in each case) very successful. Mr. Gardner thoroughly deserved the ecomiums bestowed on him by Prof. Crookes for the care with which he had prepared them. At the conclusion of the address, Sir Wm. Thomson, with characteristic enthusiasm, proposed a vote of thanks to the President, which was seconded by Mr. W. H. Preece, and carried by acclamation. We may confidently say that this address marks an era in the history of the Institution of Electrical Engineers.

James Watt Anniversary.—A dinner to commemorate the memory of James Watt was held in Glasgow on Monday night, under the auspices of the Philosophical Society and the Institute of Engineers and Shipbuilders, Prof. McKendrick in the chair. In the course of proposing "The memory of James Watt," the chairman said: "Were James Watt suddenly to appear in one of our engineering lecture-rooms, he would probably be much mystified by references to the principles of thermo-dynamics and the theory of steam, but he would find the fundamental experiments much the same as when he left the earth nearly 72 years ago." Later on he prophesied that "the time might come when tidal-power, river-power, waterfall-power, wind-power, and even the power of the sun's rays, would be utilised, and mechanical contrivances of all kinds—railways, ships, machinery—would be driven by electrical energy stored by contrivances already invented but yet far from perfect. After comparing the amount of energy got out of man as compared with the steam engine, and showing how economical nature was in the production of energy, as illustrated in the electric fish, fire-flies, and glow-worms, he remarked that it was not too much to hope that we might find how nature produced these effects on a small scale, and then we might be able to imitate them on a large scale, and with an economy to which we would be driven when obliged to stop our present rate of extravagant expenditure."

Labour Exhibition.—We have received the prospectus of "The World's Labour Exhibition" which it is proposed to hold in London this year. Elsewhere in this issue Mr. S. F. Walker is railing against exhibitions, and we are sure that in a great measure he echoes the sentiments of exhibitors. We may not agree with all he says, but of the main fact that exhibitions have been overdone there will be no denial. Nine-tenths of the exhibitions at the present time are organised because the promoters hope thereby to earn easily a good sum of money. To us this prospectus of a labour exhibition is so much clap-trap. It will be interesting to find someone looking behind the scenes and telling us how far the promoters can be termed "labourers." England seems to be a happy hunting ground with people who have un-English names, but is it not almost time that this exploitation should cease? Not to know men shows oneself to be unknown, yet, notwithstanding this drawback, who is Mr. A. Louis D. de Lavigerie, the secretary, and his co-promoters? So far as we can see, the sole object of this, as of most schemes, is to make money. Co-operators and trade unionists are to be appealed to, and, no doubt, will have to provide guarantee funds, if the affair is carried out, and it is almost as certain that such funds will have to be paid, for except the Cours d'Armour, Jeux Floraux, Kermesses et Pardons, etc., there seems to be little that is attractive in this latest proposal. Since writing the above a meeting has been held in connection with this exhibition, with the result that the promoters have been supplanted by a committee of trades unionists with whom we have no more sympathy than with their un-English *confrères*, or would-be *confrères*.

A New Sounding Machine.—Mr. S. H. James, C.E., has brought out a new sounding machine which consists of a sinker so shaped and slung that it descends to a certain position for much the same reason that a kite ascends; and having descended to its proper depth it remains there, following the ship without deviation. Attached to a slip-hook fastening to the sling of the sinker is a vertical iron lever, having a cup at its lower end for the arming or grease. A reel of wire, which is secured to the vessel's taffrail, is slung so as to be capable of swinging like a ship's bell. The vibration of the wire, owing to the great strain of towing the sinker, is very marked, and the very best wire is used. Use is made of this vibration, and the aid of a sounding-box, to indicate that the sinker is towing correctly. The action is as follows: The kite or sinker is first slung according to instructions; some arming is put in the cup, and the sinker then lowered to the surface of the water. Then, easing out the wire tow-line rapidly by means of a brake, the heavy end of the sinker dips; the strain of the passing water acts on the whole, and it goes down to its position, the sounding-box immediately setting up a rattle. On running into the depth set for, the cup-lever strikes the bottom, releases the sling of the kite, which then floats at once on the surface. The rattle of the sounding-box ceases: the wire reel, which is heavy for its size, having been pulled out of the perpendicular by the strain on the wire, now flies back and strikes a gong. The look-out man attending the machine reports that the rattle has ceased, or that the gong has struck. The ship's speed is slowed, and the sounding, perhaps, verified by a cast of the lead taken either with the same machine or with a hand-line. Mr. James's machine, which, by the way, is called the "sentry," has been tried by a coasting steamer in a run from Glasgow to London, and, we understand, gave satisfactory results. Is is also being tested on board H.M.S. "Rambler," surveying ship, in the Red Sea. Independent soundings with the ordinary lead line have been taken in cases where the "Sentry" has given an alarm, and its action has been verified as correct.

South Kensington and Paddington Railway Profs. Ayrton and Rücker have been making experiments to show the extent to which the proposed electric underground railway with this title is likely to affect the instruments at the Central Institution, and Prof. Ayrton has written to the *Times* on the subject. We make the following extract from his letter: "It may be mentioned that we did not employ any very delicate instruments, such as are necessary for physical research, but only the ordinary rough apparatus that is in daily use by students in a modern physical laboratory. Even such rough apparatus is seriously affected by mechanical vibration, and we have been led to the conclusion that the earth waves produced by the passage of large weights at high speeds affect measuring apparatus far more seriously than the noisy street traffic that rattles the windows of a house. It is impossible, therefore, to view without alarm the proposition to construct a subway for heavy tramcars within a few yards of the two important physical laboratories belonging to the Royal College of Science and the City Guilds Central Institution, both of which are used by considerable numbers of students; and our alarm is turned into dismay when we learn that the Bill which Parliament is to be asked to sanction proposes to grant powers to the new company to propel their trains electrically. For every elementary student knows that he must never walk about near even rough galvanometers, electrometers, and other apparatus used in connection with the study of those all-important practical subjects, electricity and magnetism, if either his keys, or his knife, or his watch be in his pocket. Even a tyro in the subject will not then be surprised at our observations showing that powerful electromoters on electrically-propelled tramcars constantly passing within a few yards of a physical laboratory would make even rough electrical measurements impossible. Now that the nation is devoting so much attention to the spread of technical education, now that Parliament has sanctioned the spending throughout Great Britain of considerable sums for technical instruction, is it possible that the people will allow the Central Institution of the City Guilds Institute, a building that has cost £100,000 to build and equip, and which is the centre of English technical education, to be practically ruined as regards one whole branch of instruction which is participated in by practically every single student of that college ?"

The Engineer and His Workmen.—On Wednesday evening, Mr. Robert Capper read a paper with this title before the Civil and Mechanical Engineers' Society, in the course of which he said: "The associations of workmen in trade unions at the present day were described as aggressive, defensive, and provident. Until quite lately he was under the impression that a vast majority of workmen were members of such bodies, but from the Blue-book returns, which were admittedly incomplete, this did not appear to be the fact. While the wage-earning part of the population was between five and six millions, the number of unionists did not exceed 600,000 at most. Though the total number of trade unions was over 300, a large majority of them had but a small membership, some being as low as 10. Many neither kept nor published complete records of their transactions; others objected entirely to supplying information as to their affairs, and well they might, inasmuch as one trade union of 56,000 members and an income of £28,000 had quite recently boasted that it had spent, and was spending, 22 per cent. more than it received. There was a generally prevailing idea that trade union funds were spent chiefly in fighting employers, and he had been astonished to find it officially stated that out of 39 of the principal trade union societies, with a total of 274,727 members, an aggregate of £33,729 had been expended in dispute-pay—a general average of 2s. 4½d. per member, which was a very small proportion indeed. The labour correspondent of the Board of Trade avowedly sympathised with the aims of trade unions. For this he could not be blamed from an employer's point of view, because the employers, as a class, had never given the workmen a choice of unions. Although trade unionism had made heavy drains upon the workman's pocket, it had advanced rapidly during the last year or two, and it was a question whether the time had not come for the engineer, as an employer, to brace himself up and offer the workman a choice between trade unions, a trade union with both engineers and workmen sitting at the same table or leave the workmen the prey of a paralysing influence. The majority of the strikes that had recently taken place were without any sort of justification, while agreements and stamps had been regarded as waste paper. There was, however, a large amount of common-sense among the better class of workmen, as could be seen from the resistance offered to the advanced aggressive school at congress. The remedies proposed in the matter were conciliation boards, profit-sharing schemes, and union of employers and workmen. Neither in London nor elsewhere was the first system in order, owing to the supineness of the employers."

Telephone in the West of England.—At a public meeting held last week at Exeter to consider the question of extending the trunk telephone line from Newton to Exeter, Mr. Lewis, manager of the Western Counties Company, attended, and described the growth of their system in the district. In 1883 they had 521 subscribers and 250 private wire renters, or 771 in all. In 1887 the number had increased to 2,034, and in 1890 it was 3,587. The number of calls passing through the exchanges in 1885 was 595,000, and as each call received a reply they had a total of 1,190,000 communications. In 1890 there were 3,013,000 calls, or 6,026,000 communications. This would show them what a great assistance in business the telephone was. He was sorry to see the slow growth of the system in Exeter, but he attributed this to the fact that the city was isolated and that the telephone was not of the same value there as in such towns as Bristol, Worcester, and Birmingham. In Exeter they had only 41 subscribers, 25 of whom only were paying subscribers. There were free communications with the police station, fire-engine station, and other places. Strange to say, the hospital had not accepted their offer to connect them with the exchange. He did not know the reason, but he hoped before long the governors would change their minds. Mr. Lewis then went on to explain the system of trunk lines, and said at present there was an important break in the system—namely, between Weston-super-Mare and Newton. If the line was only completed, it would place them in communication with 3,000 subscribers; if it was only constructed between Newton Abbot and Exeter, it would connect them with 500 traders—300 at Plymouth, 200 at Torquay, and others at the smaller towns. The cost of making the short line would be about £1,200, and the longer one about £3,700. If the company saw a prospect of receiving any reasonable support at Exeter, Bridgwater, Taunton, and Weston-super-Mare, they would be prepared to undertake this outlay; but their company was one trading for a profit, and of course they had to consider the shareholders' interests as well as those of the customers. If the work was only carried out Exeter would then be in communication with Worcester, Birmingham, Liverpool, and Manchester. It was said sometimes that the annual rental of £10 was heavy, but it was hoped if the royalties could only be abolished that the charge might be reduced. Mr Houlditch asked if the outcome of the meeting could not be practical. Let them secure 25 additional subscribers, and then Mr. Lewis could go to Taunton and secure another 25. In that way they would soon be placed in communication with towns in the North and with London. Mr. Lewis said if he could get 55 additional subscribers in Exeter, Taunton, and Bridgwater, he would recommend the directors to expend the £5,000 in constructing the longer trunk line. He thought they might in 18 months' time have connection with London. After further discussion and explanations, the proceedings were brought to a close, the Mayor and other gentlemen offering to become subscribers.

UNDERGROUND MAINS.—II.

THE CROMPTON SYSTEM.

(Concluded from page 74.)

The culverts when going under roadways have to be made of extra strength to carry the heaviest traffic without fear of the covers breaking or the side walls crushing in. Certain regulations have been issued by the London County Council, and the designs of culverts and covers given are constructed fully to comply with these requirements. The trenches in these cases are about 4ft. deep. The illustrations show cross sections and longitudinal sections of a 2ft. culvert under roadway. The smaller culverts are of similar construction, the only difference being in the width. The culverts have a solid cement bottom, and the walls are of 9in. brickwork set in cement and with an inside coating of cement to prevent any percolation of moisture.

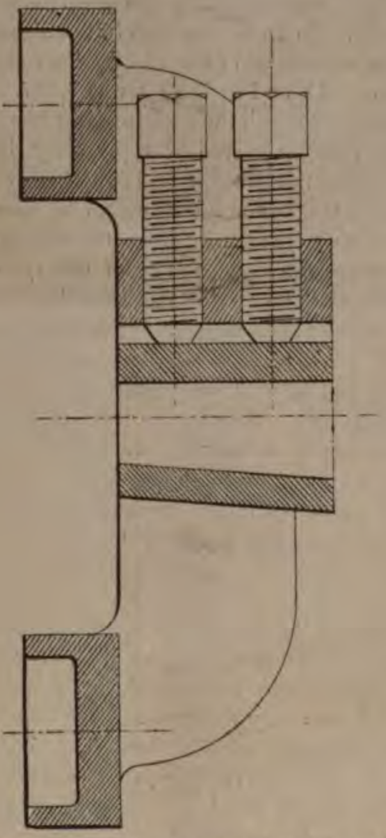


FIG. 13.—Straining Bridge.—Section, showing wedge-shaped opening for gripping copper strips.

They are also sometimes constructed entirely of cement 9in. thick. Two methods of covering the culverts are adopted according to judgment. They are either covered in with two thicknesses of 2¼in. York stones; or in some cases with cast-iron covers having ribs on the upper surface and filled in with concrete. Both these methods are shown in the illustrations, Fig. 7 being a longitudinal section of a culvert, half of which is covered with thick York stones, and the other half indicating the culvert as covered with ribbed iron plates and concrete. Fig. 16 is a reproduction from a photograph of the work of trenching.

The covers to the boxes under the roadway have, of course, to be adapted to the nature of the rest of the roadway surface. Both the insulating and straining boxes are dealt with in the same way. The covers are made of a cast-iron frame, hollow on the upper side, fitting into the boxes and easily removable for inspection. The hollows in the upper surface are filled in with concrete, cement, asphalte, or other material, to match both the colour and the rate of wear of the material of which the roadway itself is constructed. The joints of these covers are made water-tight, and at the same time noiseless, so as not to vibrate under the traffic, by inserting a serving of tarred rope in the framework of the box before the cover is put on. Where wood pavement is in use, the cover is made with ribbed openings of the necessary size to match the rest of the pavement, and hard wood blocks are cemented in, as shown in the illustration, Fig. 9. The arrangements for connecting a culvert under a roadway with that under the pavement are seen in Fig. 8.

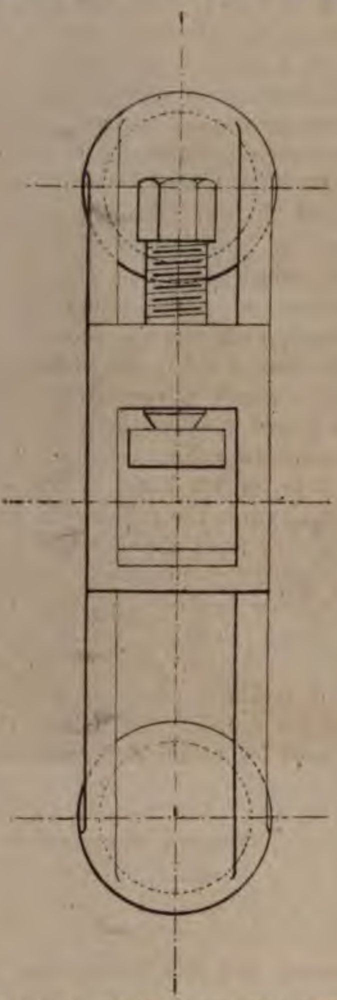


FIG. 14.—Straining Piece.—End view.

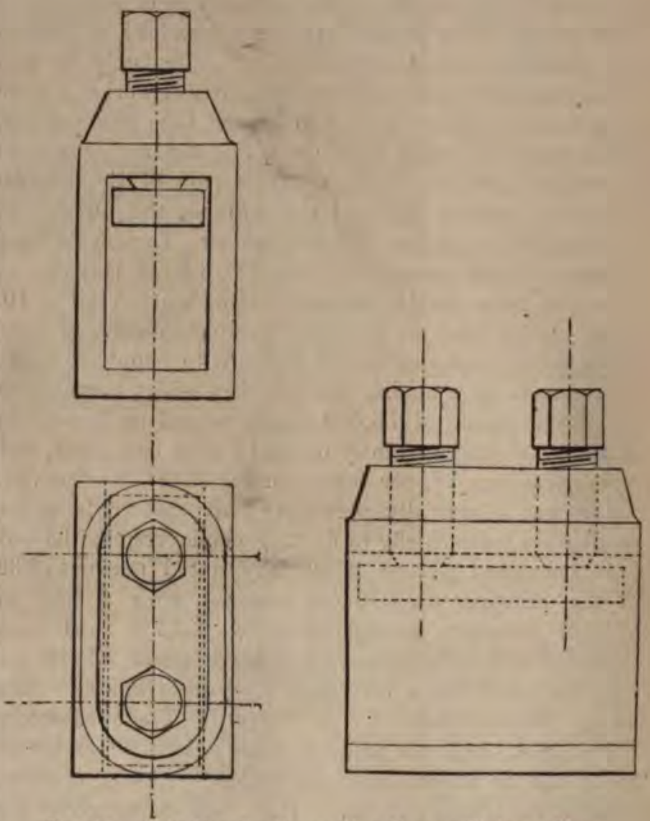


FIG. 15.—Grip Box for Connecting Copper Strips.—Plan, end, and side view.

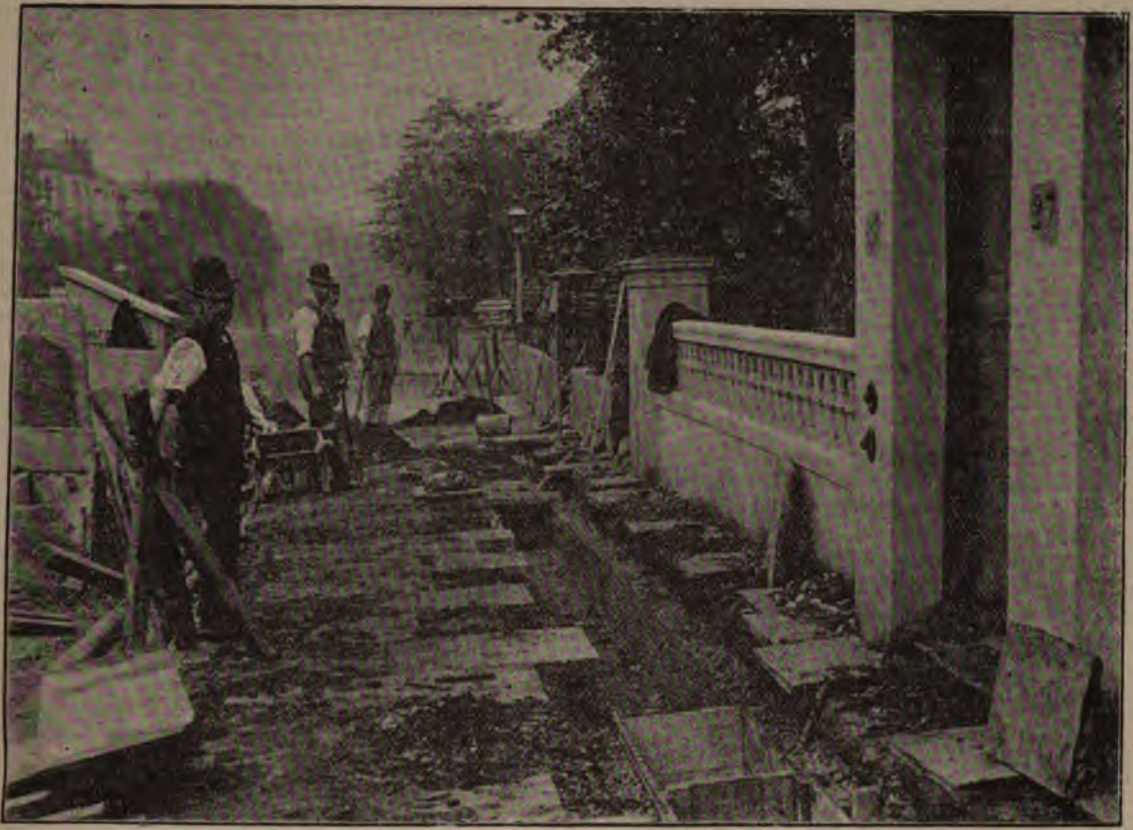


FIG. 16.—Trenching and Cementing.

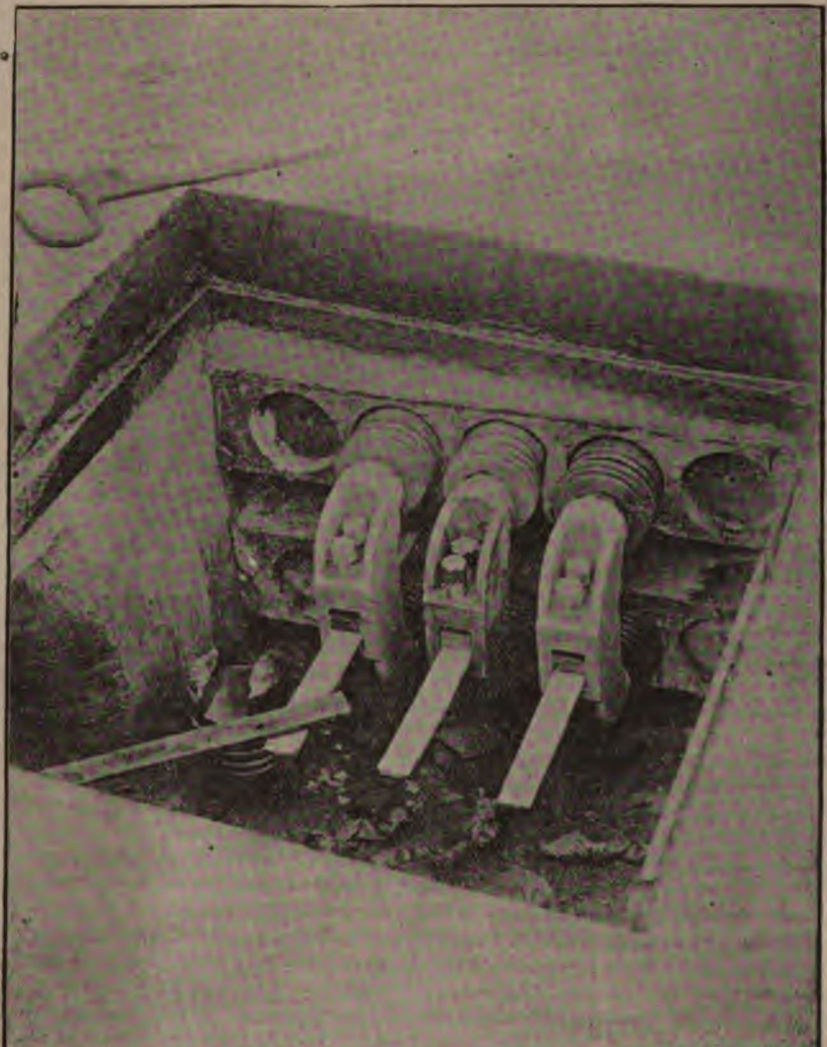


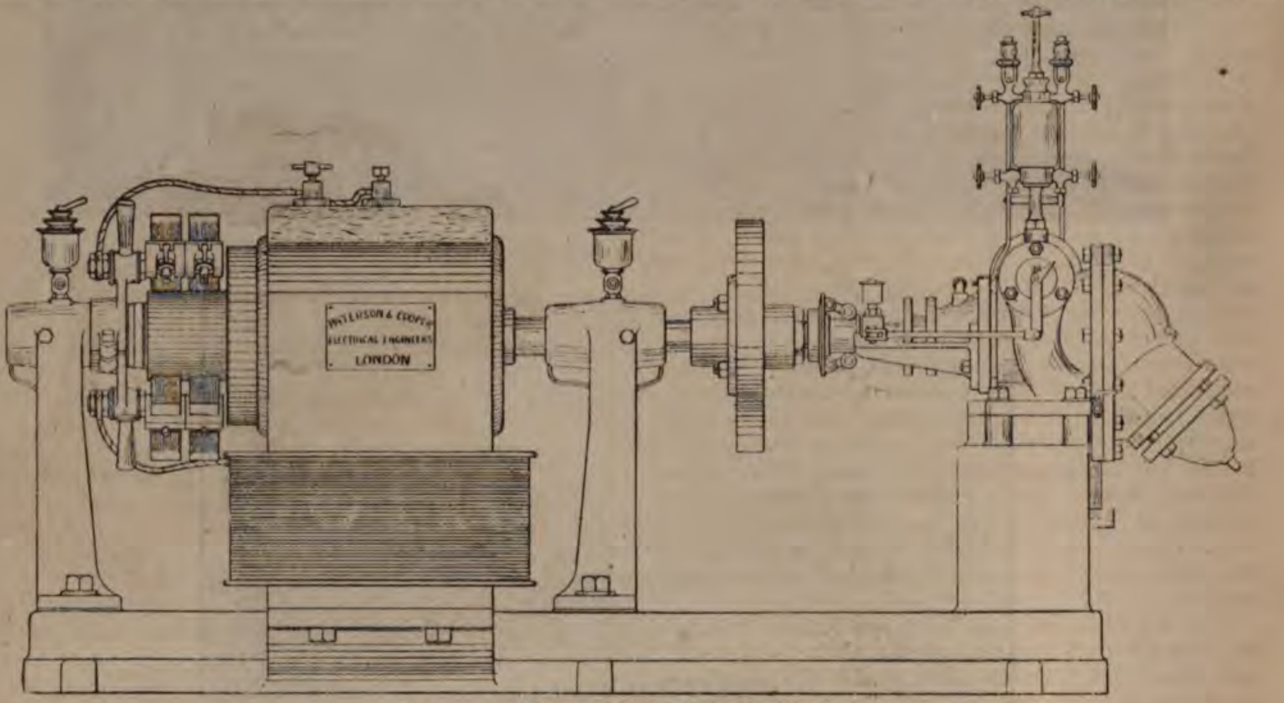
FIG. 17.—Straining the Cable.

It sometimes happens that the space under the footway is so small that culverts cannot be built. In such cases heavily-insulated cables drawn into pipes are used for the distance required, each cable having its own separate pipe.

The ends of these pipes are brought into insulator or straining boxes (Fig. 17) of the same form as those used for the culverts, and the cable is screwed tightly to the copper strips in the manner shown. Similar arrangements are adopted for connecting the house mains to the three-wire mains. They are led to the nearest insulating box, and are connected respectively to the inner main and one of the outer mains. If it is ever necessary to alter the balance of the current in the two halves of the three-wire mains, it is a matter of a few minutes' work to lift the cover, unscrew one end of the house main, and screw it upon the opposite outer main strip.

PATERSON AND COOPER'S SHIP LIGHTING PLANT.

The accompanying illustration shows a Phœnix dynamo driven direct by a Tower engine. This combination has been designed by Messrs. Paterson and Cooper for ship lighting. The dynamo gives 92 amperes at a pressure of 100 volts, running at 550 revolutions per minute. Four combinations of this kind have recently been supplied to a firm of shipbuilders to be placed in duplicate on two large steamships, the specification limiting the rise of temperature in continuous running to 25deg. C. or 45deg. F. above the surrounding atmosphere. The machine in reality runs without heating to anything like this extent, and will usually give an output of 25 per cent. above the normal without any undue heating or sparking.



Paterson and Cooper's Ship Lighting Plant.

THE KEYS ELECTRIC COMPANY.

Hardly a week passes but we insist to our readers upon the importance of the speedy introduction of electric motors to the better notice of the general public in our large towns. We insist for two good reasons: that the enormous demand for electric power which inevitably must spring up, in houses and in smaller workshops, will itself be a boon to private householders and to small manufacturers when the advantages of the use of electric energy are fully known and appreciated; and we insist again from the point of view of the supply companies, who not only have a further large field for supply of current to be tapped, but that this supply tends constantly to fill up the idle hours of the day, to swell out the load diagram, and give that result dear to electrical engineers, an economical, because constant, generation of electricity.

The first necessity, we suppose, for this wide appreciation of the advantages of the electric motor is a permanent exhibition, where the household apparatus, such as knife-cleaners, sewing machines, and washing machines, and all the other minor mechanical aids to civilisation's progress, might be beholden by whoever will in actual operation at their very doors, not to speak of the really more important examples of turning lathes, churns, and other manufacturing appliances driven electrically.

Even at the public electrical exhibitions these utilities, though occasionally present in odd corners, have been presented by English manufacturers in no striking *ensemble*, no telling adaptation appealing at once to the alert manager and the good housewife. These things, we say, ought to be done, for public opinion must be trained to the advantages of the clean, easy, and silent electric motor.

Well, as no English company and firm are taking up the matter in the manner it should be done, the Germans are going to show us the way. We confess we should better have liked to see the initiative on such an important point taken by English companies for English manufactures, but better have it done by competitors than not done at all, and certainly the lead is being taken by a poweful firm, whose reputation on the Continent is almost second to none, and whose products we have in England had as yet no opportunity of seeing. We allude to the Allgemeine Elektricitäts Gesellschaft (General Electrical Company of Berlin), the outcome of the old German Edison Company.

A company has been formed in England under the name of the Keys Electric Company, Limited (having bought up a small private company of that name), who have taken spacious and imposing premises in the centre of London at 122-124, Charing-cross-road, and opened therein a permanent exhibition of electric light in action, electroliers, instruments, dynamos, and motors, the latter both for heavy transmission of power and also embodying many useful applications of small electric motors to ordinary household work.

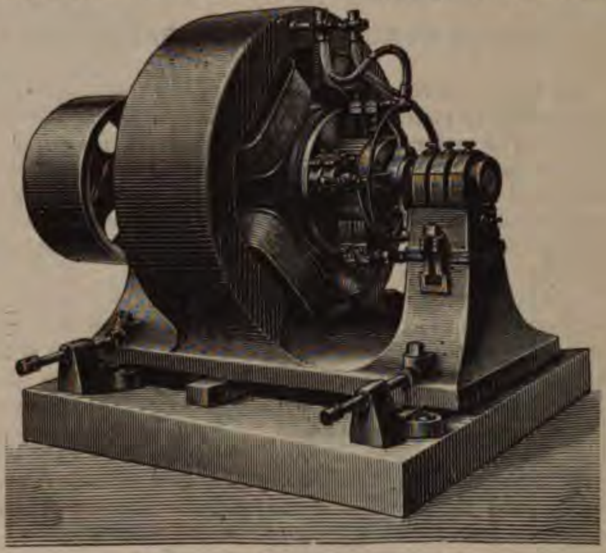
The company act as sole agents for the introduction and sale of the numerous specialities of the Allgemeine Elektricitäts Gesellschaft of Berlin, and is practically under the same direction. Mr. A. Reckenzaun is consulting engineer to the new company.

A few words as to the position and scope of the Allgemeine Elektricitäts Gesellschaft may not be out of place here, for, although their work and standing is well enough known to some of the electrical profession, to many others this powerful continental company is little more than a name. The company have now a capital of 20,000,000 marks, that is, of £1,000,000 sterling, of which their former capital of 16,000,000 marks has lately been increased by 4,000,000 marks, at 80 per cent. premium, the 1,000 mark shares offered selling for 1,800 marks, and the new issue of four million being thus sold for 6½ million marks. They have paid a dividend of 10 per cent. during the last two years, and in addition to this have written off more than five million marks (£250,000)—their patent account, on which they have spent over one million marks, now standing in their books at one shilling. This is a result which we suppose no other electrical company can show in its balance-sheet, and is in itself a marvellous commentary on the activity and enterprise of the Berlin company. They have a large machine factory in the Ackerstrasse employing 1,200 hands, a lamp factory in the Schlegelstrasse, of which the output is 4,000 to 5,000 glow lamps a day. The Central Station Company of Berlin (Berliner Elektricitäts Werke) is a branch of the same concern, under the same directors with separate capital, having now nearly 15 million marks (£750,000) invested in central station plant and buildings. There are four large central stations in active operation, having all their systems of underground mains connected together in a manner to be able to help each other in supply when necessary, the total capacity at present being equal to 150,000 16-c.p. lamps simultaneously, and additions to the central station capacity of 100,000 lamps are in course of construction. Besides this, the Allgemeine Elektricitäts Gesellschaft is interested in many separate electrical enterprises. Of these the Neuhausen Aluminium factory is perhaps the most important, having a capital of very nearly 10 million marks. The Tudor Accumulator Company is another, having four million marks invested. In the Madrid central station they are the principal shareholders, holding half the shares, and are the constructors to the station; and there are various other electrical enterprises in which they are equally interested. It is this company for whom the Keys Electric Company are acting as English branch for the supply and exhibition of electroliers, switches, switchboards, instruments, and dynamos; and with a working exhibition for pushing the use of motors for domestic and industrial purposes. It may be mentioned that the large engineering works of the Allgemeine Company in the Ackerstrasse are run entirely by electric motors, every machine—planing, boring machines, lathes, and other machine tools—being fitted each with their own separate motor, and the cost of power is found no higher than by steam, while the convenience is far greater. As an illustration of the extended and economical use of the electric motor these works afford in themselves a fine example.

The premises taken by the Keys Electric Company in the new Charing-cross-road, at the Oxford-street end, are very spacious and commanding, giving two long floors for showroom purposes, besides upper floors and offices. The electrolier showroom is upon the first floor, and is likely to be found one of the finest shows of fittings in London. It is filled with electroliers of very varied and ornate type, mostly made by the manufacturing company in Berlin, but showing also many specimens of ornamental fittings of the best makers in France and with others of English manufacture. In this showroom there are in all a total of 350 lamps, wired ready for lighting, on 100 different circuits, each of which can be separately switched on by means of four distributing switchboards. Very many handsome and striking pendants are to be found amongst this selection.

On the ground floor are a large number of dynamos and motors. The dynamos range from 2½ unit to 25 unit, of double-pole type with solid yoke. A special feature of the dynamos is the short-circuiting of the magnetic pole-pieces, an arrangement adopted to prevent sparking at the brushes. A ring of soft iron encircles the armature, being inserted between the bored-out pole-pieces, so as to connect them across by the thickness of its ring. At the top and bottom this ring is slotted out in oblong holes, or thinned down, and drilled out in a series of small circular holes so as to leave only a slight sectional area of soft iron, absolutely short-circuiting the poles. The electrical efficiency of the machines is given at 95 per cent. The motors are of a similar type, with an outside circular yoke, having several inside pole-pieces and magnet windings. Considerable attention has been given to the construction of these motors to render them effective and efficient, and it is this type of motor which is employed as mentioned to drive the works, and in many installations for the transmission of power carried out on the Continent.

On the same floor is the permanent exhibition of electric motors in working order, to which we have alluded. Small ⅛th h.p. motors of Crocker-Wheeler type are used in some cases, and motors of their own manufacture are being fitted up shortly for similar as well as for heavier work. We see one of Pfeil and Co.'s lathes steadily whizzing around on the turning of a small switch, the motor being arranged alongside on the floor, and driving by means of a tiny line of countershafting. In another corner is a Blackman fan, used to ventilate the accumulator-room below—a very useful application. Then is encountered a whole set of domestic mechanical contrivances, all merrily rotating by the aid of the little motors. There is one of Bradford's well-known knife polishers, with several other of the same maker's aids to quick work, a boot cleaner, with its various brushes—dirt brush, blacking brush, and polisher—sticking grimly out ready for the family's morning supply of boots. Further along is a washing machine, with its uncouth wooden box for dirty linen and its screwed down lid; and alongside, a wringing machine, with its wooden rollers, grievously suggestive of wet sheets and weary arms—henceforth mildly working by the turning of the electric button. There is a churn, there are sewing machines—but why go on? There is just exactly what the advanced housewife of the day—at whose house the electric light has been turned on—wants to complete her happiness and her belief in the successes of science. And all these machines are made to connect to the 100 or 110 volt circuit, and the motor takes ·6 of an ampere—that is, almost exactly the equivalent of one incandescent lamp. A considerable demand is springing up for sewing machines, and one of the Keys electric sewing machines was being packed for use on the station circuit in Madrid.



Allgemeine Company's G Dynamo.

From the ground floor we can descend by an electric lift—or, rather, will be able to descend, for the installation of the lift is hardly complete. In the basement is the engine-room, a very neat and comprehensive installation of considerable output. There are two gas engines driving two of the company's dynamos. A high-speed Crossley gas engine, giving 15 electrical h.p., drives one of the old type Edison machines, 100 amperes and 110 volts, of the type made by the late German Edison Company, and a Griffin gas engine, giving 8 h.p., drives one of the Allgemeine Company's newer type dynamos. In a side room is a set of E.P.S. 31L accumulators. The switchboard is of the Allgemeine Company's make, fitted with Dolivo ammeters (also made by them), which are already known in this country. The switchboard has two ammeters and a voltmeter, with main and regulating switches fitted with spring-snap action, and an automatic cut-out of their own type for use when charging the accumulators. An Aron meter is used to measure the current supplied. This is a meter much used by the company, although they will shortly, we understand, probably adopt the new and simple type of electric meter invented by Mr. Reckenzaun.

Going again to the ground floor, there are arc lamps and many instruments to be seen. The arc lighting is arranged on the indirect system, by which the lamp globe is covered in below by an opaque shade, and the light reflected upwards upon the ceiling, giving a well-dispersed illumination. A new type of arc lamp will shortly be on view here designed by H. Pieper, the Belgian electrician, being extremely simple in its action and without clockwork, dependent simply on the differential action of the two polarities of the current. Besides the Dolivo volt and ammeters already mentioned, the Keys Electric Company have numerous scientific measuring instruments made by Dr. Edelmann, of Munich (the German Elliott Bros.), resistances, galvanometers reflecting and tangent, testing batteries, calorimeters, etc. One water resistance is interesting, being for the heavy current of 1,000 amperes, with extremely heavy contacts and circulating water baths. There are also quick-break switchboards of the Allgemeine Company's type, shunt resistances for dynamos or for arc lamps, Edison and other fuses. An automatic potential regulator by Cuenod, Sautter, and Co., of Geneva, worked by means of magnetically governed coned double friction wheels is for automatically regulating the E.M.F. of dynamos for lighting. Numerous small motors are quite the feature of the place, together with a further display of handsome pendants in the showroom windows.

OULTON-EDMONDSON ELECTRIC METER.

We have received the description of the Oulton-Edmondson electricity meter, of which an illustration is herewith given. The meter is upon the principle of measurement by the retardation of two similar pendulums, one being influenced by the electric current. The meter is both for continuous and alternating currents, and embodies some novel arrangements for the simple and exact realisation of its objects.

In a few words, the meter consists of clockwork with twisting pendulums of the kind familiar to those who have seen the "400-day clock." The left-hand pendulum is connected with two swinging solenoids which affect the speed of this balance as compared with the other. In the figure the two heavy circular balances are seen hanging by long thin strips, the "torsion spring," with the clockwork and dials between them. Below are the two swinging coils, and around the lower one the main conductors of strip copper are seen. Below these are two mercury cups, and to the right the negative and positive main terminals. In the upper corner is a fixed resistance coil, and above this the terminal for the high-resistance circuit.

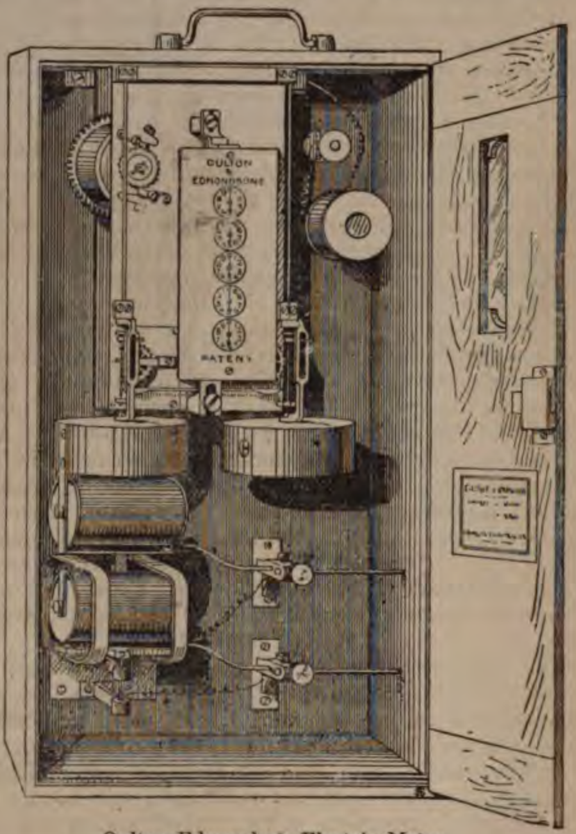
This wattmeter, therefore, consists of a set of clockwork with two torsion balances, which keep identical time except when current is being used. When a current passes through the main conductor it quickens the speed of one of the balances, and the difference in speed, registered on the dials in Board of Trade units, is a measure of the current consumed. A difference of 10 beats an hour equals one Board of Trade unit, and the measurement is proportional to the current throughout the whole range for which each instrument is constructed.

The clockwork is of first-class quality, with "high numbered" pinions. Both balances are driven by one main spring, the force of which is equally divided between them by a novel differential gear, and their synchronism is therefore practically perfect.

The electrical arrangements consist of two compound-wound solenoids, astatically attached to one of the balances, and swinging, the one above, the other within, the coils of the main conductor, and influenced by the current to be measured.

The principal winding of the swinging solenoids consists of fine wire, connected with a fixed resistance coil, by which the instrument is calibrated, and coupled across the supply terminals. In a 100 ampere-meter these high-resistance or volt coils consume about ·007 ampere on a circuit of 100 volts. By themselves, however, they would not give proportional readings, for the reason that in pendulums and chronometric balances, the force required to produce the vibrations is proportional to the square of the number of vibrations in a given time. If, therefore, a = the normal number of vibrations, and b = the number to be added by the current, the force required to produce a will be a^2 and to produce $a+b$ will be $a^2+2\,a\,b+b^2$; the difference $(2\,a\,b+b^2)$ being the force to be exerted by the current under measurement. With the volt coils alone, the force actually exerted would be in the ratio $2\,a\,b+b$ only. Upon each volt coil, therefore, there is wound a "correcting coil," carrying a very small proportion of the current passing into consumption. If correctly calibrated, this small current brings the ratio up to $2\,a\,b+b^2$. This correction is made mathematically perfect, and makes the readings absolutely proportional throughout any range.

In meters in which the influence of the current on a vibrating pendulum or chronometric balance is the basis of measurement, the element of friction is entirely dealt with by the force of the clock, which supplies power exactly in proportion to the speed of vibration. The current under measurement has, therefore, no friction to overcome. Hence such meters register the smallest as accurately as larger currents. The following are the details of the meter:



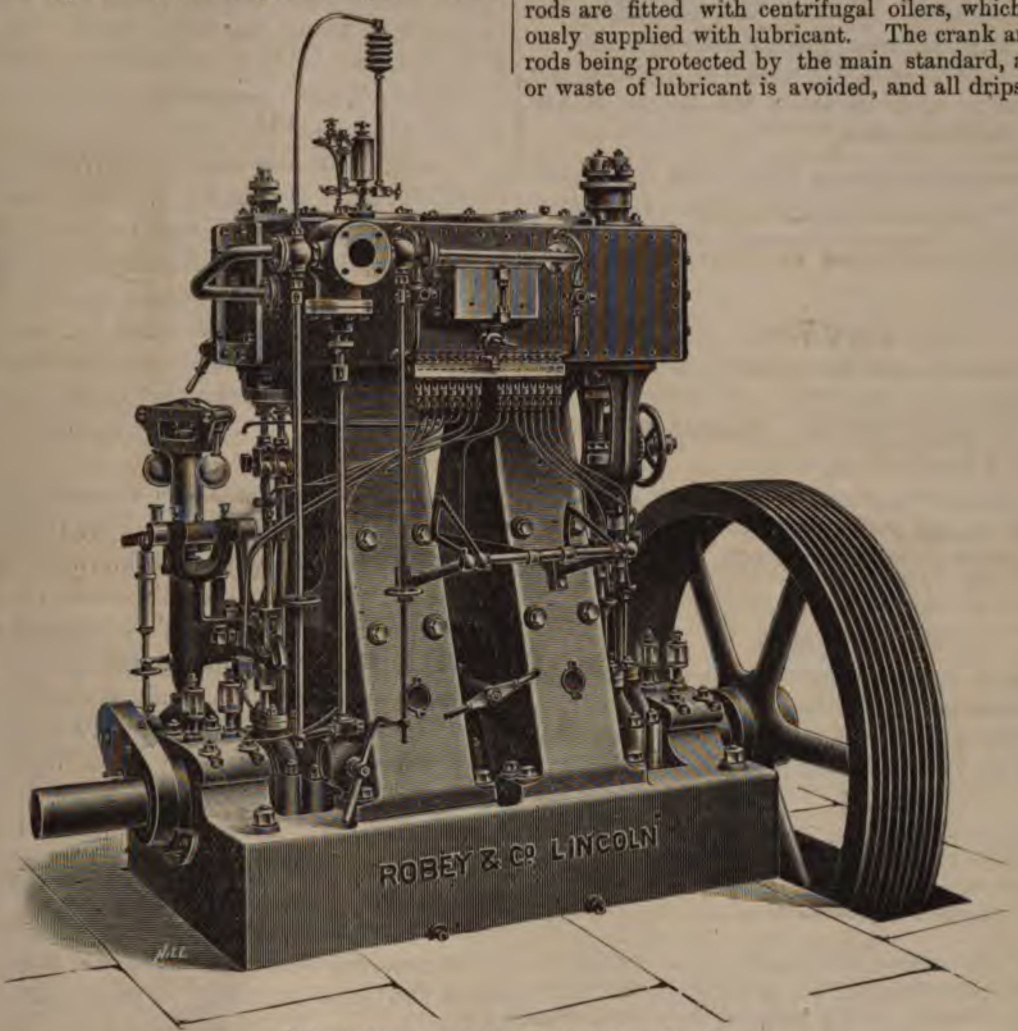
Oulton-Edmondson Electric Meter.

The external dimensions are 19½in. high, 12½in. wide, 6½in. deep. The right-hand balance weighs about 4lb. It contains two "timing screws," which are really small weights, which, when screwed inwards, will quicken and when screwed outwards will retard the speed of the vibrations. The number of vibrations is about 15 per minute. The balance-spring, instead of being coiled as in a watch, is quite straight, acting in torsion, and forms the means of suspending the balance, which thus vibrates practically without friction. The left-hand balance with its solenoids are made of the same weight as the above, so as to vibrate in the same period of time. Although driven by the same mainspring, the two balances are free to move independently.

The current for the volt and correcting coils is conveyed from the positive terminal to the mercury cup, placed concentrically with the left-hand balance, into which a wire upon, and concentric with, the balance projects. After traversing the volt coils it is conveyed up the "torsion spring," and through the fixed resistance coil to a terminal near the top of the case, and thence to the negative main. The current traversing the correcting coils returns through the upper mercury cups to the negative terminal of the instrument. This current is very small, as for one ampere on the 100-volt circuit it has to furnish a magnetic force equal to only $\frac{1}{1800}$ of that furnished by the volt coils. As, however, the turns in the correcting coils are much fewer than those in the volt coils, the actual current in the former may be (for one ampere) somewhat greater than in the latter, and it increases in proportion to the current consumed.

The denominator of the fraction $\frac{1}{1800}$ is the $2\,a\,b$ of the difference $2\,a\,b + b^2$ mentioned above, when the balances normally vibrate 900 per hour.

The advantages claimed for the Oulton-Edmondson meters, which are made by Mr. Joseph Edmondson, 36, Sunbridge-road, Bradford, are that their synchronism is much more accurate than has been attained in previous meters acting on the same principle; they will go for three months without rewinding, even when worked up to their full capacity; they will measure any current however small; they give proportional readings over a longer range than any other mechanical meter extant; the electrical energy consumed is less than in any other existing watt-meter; the dials register the consumption in plain Board of Trade units; and, finally, that there are no "make and break" contacts.



Robey's Compound Electric Lighting Engine.

ROBEY'S COMPOUND ELECTRIC LIGHTING ENGINE.

Messrs. Robey and Co., of Lincoln, have paid just attention to the construction of engines for electric lighting purposes, and have designed a series of engines especially for electric light installations. These engines vary in power from 40 to 200 i.h.p. The engine, as illustrated, has high-pressure cylinders 11in. diameter, low-pressure cylinders 18in. diameter by 12in. stroke, and makes 200 revolutions per minute, though it can be worked up to 250 revolutions. The crankshaft is 6in. diameter, and has three bearings, with a total length of 32in. All the working parts have very large wearing surfaces, and the engine throughout is of most massive build. Every part is carefully balanced, and the right provision made in the set of the valves, so that the engine can be run at the high speed of 250 revolutions per minute with ease and safety. There is a total absence of vibration or shock. All the working parts are well lubricated from a central oil-box, which is fitted with a gauge showing its contents, and each separate point to be oiled has an independent adjustment with a visible drop feed.

The engine is governed automatically by link expansion gear controlled by a powerful Richardson governor, and not more than 2 per cent. variation in the number of revolutions is made between all load on and the engine running light, while with ordinary changes of load the variation is imperceptible. The governor is driven direct from the shaft through machine-cut wheels which are enclosed in a casing. The weight of valve rods is compensated by means of steam plungers, so that the whole motion is in complete balance. The governor is also fitted with an extra adjustment, by means of which the speed can be varied while the engine is running, and set at any required number of revolutions. The large ends of the connecting rods are fitted with centrifugal oilers, which are continuously supplied with lubricant. The crank and connecting rods being protected by the main standard, any splashing or waste of lubricant is avoided, and all drips are collected in suitable wells in the base-plate, from which all the oil can be removed by passages and cocks arranged for the purpose. The lower part of the columns on the front side is arranged to be removed when it is required to examine the crank-pin, or to take out the crank, and this can be quickly and easily done without disturbing any other part of the engine. All the levers and handles are brought conveniently together in front of engine, so that the starting valve, intermediate receiver, drain cocks, and governor adjustment can all be attended to from one position. The engine may be used to drive a dynamo direct, or with belts or ropes. The engine the particulars of which have been given has been made for the Newcastle-on-Tyne Electric Supply Company, and drives a 37-unit Mordey Victoria alternator, which developes 70 to 75 h.p.

This company has in its Newcastle station three other coupled compound engines of Messrs. Robey and Co.'s make, like the one illustrated, each of 200 h.p., and which are used during the evening. The smaller one is used for day lighting, and to work during the day and night in conjunction with one or more of the larger engines.

THE

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

1891.

In telephony there is little of a definite character to relate. In London the system is unsatisfactory. A portion of the controlling patents has lapsed, and within another six months or so, another monoply badly managed in the metropolis of the world will have passed away. It must be conceded that the existing management has not had time to retrieve the fortunes of what might have been the most gigantic business concern of modern times outside the Government. We have usually selected the Western Counties and South Wales Telephone Company as an example of how energy and common sense will send business along, and the figures on page 93 will indicate that during the past year there has been no lack of enterprise. The opening of trunk lines, the giving of concessions to subscribers, are all steps which add to prestige and to income.

Passing from the work of private companies to that of the Government, we have the most important telephonic work now in hand that has ever been undertaken in this country. We refer to the telephonic connection between London and Paris, which it is hoped will be completed some time next month. It will be time enough to discuss the whole question when the work is complete, meanwhile the proceedings are being watched with great interest.

"Of the making of books there is no end," and the remainder of the verse is by this time of the world's history pretty well known. Most of the people one meets are not disposed to trouble themselves much about Solomon's wisdom, for, say they, the study of books means knowledge, and knowledge means money. We are inclined to think that however illnaturedly some books may be spoken of, no book ever issued from the press but it had good points. There is no doubt, however, but that in the majority of cases the good points are hidden, while the bad points are like thorns, making themselves felt. It has been said that a man's character is known by the company he keeps, and that is so, yet a great deal more than character can be told if we know the books he reads. Fortunately for the few, the major part of those engaged in industrial occupations are not readers, either of technical books or technical papers. The few who want to know get to know, and gradually rise above the ruck of their fellows. They must, however, be workers as well as readers, otherwise their ultimate position is far below what it might be. Again, the omnivorous reader is better than the man wedded to one book or one paper. Dean Cust put this very pithily and pointedly once to us. His conclusion was that the man who read and swore by one particular paper was not far removed from absolute ignorance, taking all that was told him by this one paper as gospel, never asking if there was another side to the question, and never thinking about it at all. What was said in his particular paper was said, and was right, and that ended all discussion. Most men find it exceedingly difficult to "think"; hence they choose a hero whom they

THE WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY, LIMITED.

The company was formed in December, 1884, for the purchase, working, and extension of existing telephonic exchanges, and establishing others, as well as for the supply of telephones to the general public. It has now in operation telephonic exchanges in the following places—viz. :

Bristol.
Clifton.
Bath.
Gloucester.
Cheltenham.
Shrewsbury.
Worcester.
Newport.
Cardiff.
Penarth Docks.
Barry Docks.
Pontypridd.
Aberdare.
Tredegar.
Merthyr.
Briton Ferry.
Port Talbot.
Neath.
Morriston.
Swansea.
Llanelly.
Weston-super-Mare.
Exeter.
Plymouth.
Devonport.
Mutley.
Plympton.
Torquay.
Paignton.
Newton Abbot.
Totnes.
Ashburton.
Buckfastleigh.
Brixham.
Dartmouth.
Bournemouth.
Poole.
Portsmouth.
Southampton.
Winchester.
Weymouth.
Jersey.

TRUNK LINES COMPLETED CONNECTING TOWNS.

Total route, 478 miles. Length of trunk wires, 2,215 miles.

Bristol and Bath
„ „ Sharpness
„ „ Gloucester
„ „ Cheltenham
„ „ Newport
„ „ Cardiff
„ „ Penarth Docks
„ „ Barry Docks
„ „ Pontypridd
„ „ Pontypool
And with each other.

Bristol and Aberdare
„ „ Merthyr
„ „ Tredegar
„ „ Swansea
„ „ Morriston
„ „ Neath
„ „ Briton Ferry
„ „ Port Talbot
„ „ Llanelly
And with each other.

Portsmouth and Southampton
„ „ Bournemouth
„ „ Poole
And with each other.

Plymouth and Devonport and Torquay
„ „ Paignton
„ „ Newton Abbot
„ „ Totnes
„ „ Buckfastleigh
„ „ Ashburton
„ „ Plympton
„ „ Brixham
„ „ Dartmouth
And with each other.

Also Bristol and Worcester, and to boundary of National Telephone Company's district, communicating with Birmingham and other midland and northern towns which are now connected.

The extension to Birmingham will enable the Bristol, Bath, Gloucester, Worcester, and South Wales subscribers of the Western Counties Company to speak to many towns in the midland district, and to Liverpool and Manchester.

RAPID GROWTH OF THE COMPANY'S TRUNK LINE BUSINESS.

Period.	Mileage of wire.	No. of calls.	No. of communications, each call receiving a reply.	Receipts.
4 months to December, 1887	922	27,338	54,676	£262 17 3
12 „ „ „ 1888	1,387	142,443	284,886	1,349 5 7
12 „ „ „ 1889	1,804	184,754	369,508	1,853 11 1
12 „ „ „ 1890	2,215	248,260	496,520	2,774 17 0

NOTE.—The month of December, 1890, is estimated at $\frac{1}{11}$th of the previous 11 months.

STATEMENT SHOWING PROGRESS OF THE COMPANY'S BUSINESS FROM ITS FORMATION.

Date.	Renters.			Period.	Rentals accrued and sundry receipts, less royalties.
	Exchange and trunk.	Private.	Total.		
31st December, 1885	522	257	779	16 months ending 31st December, 1885.	£7,747 17 5
31st December, 1886	993	325	1,318	Year ending 31st December, 1886	8,063 13 1
31st December, 1887	1,572	462	2,034	Year ending 31st December, 1887	12,700 17 0
31st December, 1888	2,054	556	2,610	Year ending 31st December, 1888	17,396 10 11
31st December, 1889	2,392	671	3,063	Year ending 31st December, 1889	21,285 13 8
11 months in 1890	2,837	703	3,540		

FREE USE FOR COMPANY'S SUBSCRIBERS OF CALL ROOMS IN ALL TOWNS IN THIS COMPANY'S DISTRICT.

In October last the directors arranged to issue three free call room passes to each subscriber applying for them in respect of each exchange connection, and they have now decided to extend the benefit so as to enable a subscriber or his representative to use the pass for local calls in any town in which he may happen to be, and they do not doubt this convenience will be appreciated by the subscribers. This new facility came into operation on January 1st, 1891.

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worship. What he says they say; what he does they ape. Just so with technical books and papers. If Smith's hero says sea-water is green, Smith says it is green; so Jones says it is "blue" because his hero says it is blue. Neither Smith nor Jones trouble to decide for themselves. Authority—authority—authority is the cry, and he who resents authorities crammed down his throat is anathema. We are led to indulge in remarks of this kind by a thought of the success of Mr. F. C. Webb's little book issued in 1862, as compared with the success of books a million times inferior during the past year. Then it was more difficult to sell one copy than to sell a thousand now. Part of this difference is due to the conditions existing, but not all. No man living or dead had, previous to Mr. Webb's work, so ably discussed the true principles upon which certain electrical calculations must be based. Years after these principles had hardly permeated among the class whose ranks are supposed to stand in the forefront of science. It took long years before the labours of Cavendish and Green were recognised, and we desire a less lengthy period to elapse before giving Mr. Webb that credit to which he is justly entitled. "The earth a reservoir" was generally held till Webb demonstrated the utter rottenness of the doctrine and proved his point up to the hilt.

A number of books have been issued within the past year, which, for one reason or another, have not yet received the notice they merit in our columns. We shall, therefore, refer briefly to the most important of these books, some of which we believe ought to be in the hands of every member of the industry.

"ELECTRIC TRANSMISSION OF ENERGY," by G. Kapp, C.E. (Whittaker and Co.).—This book has now reached a third edition, and although the new edition does not differ materially from the previous one, care has been taken to revise and incorporate when necessary. Up to page 124, for example, the editions are verbally the same, then come transpositions, additions, and elisions; then again textual similarity, and so on. When the first edition of this book was published we expressed our opinion as to its value—time has not altered our opinion. Mr. Kapp knows that on certain electrical questions we differ; yet, while differing, it must be acknowledged that no other man has done more to enlighten his fellow-men upon what may be termed the technics of his profession. His papers before the Institution of Civil Engineers, before the Institution of Electrical Engineers, have been pre-eminently practical, while this book provided for a new field—one that must be of great magnitude, and one that was and is little understood. There is one suggestion we might venture to make.

A number of suggestions, emanating from others than the author, are given. Some of these are never likely to come into practical use. A number of dynamos are described and illustrated, and are evidently given a place because the author desires not even to seem to select one maker before another. Unless there is some really distinctive feature in each dynamo to require a description, there is no need to pile up the number described. In the near future we are likely to accumulate a mass of information which, when duly digested, will require all the space that Mr. Kapp can spare in future editions. The only way, so far as we can see, in which the space can be obtained without adding materially to the bulk of the book, is to leave out unworkable suggestions, and the repetition of descriptions. Mr. Kapp, no doubt—in fact, he must have done—noticed the somewhat hazy notions existing among engineers cropping up during the discussion at the Institution of Civil Engineers as to the efficiency of an electric system with and without a motor in the system, and these hazy notions will not be cleared up till further information is given to those who make the mistakes. Mr. Kapp's book goes a long way, and gives a large amount of very valuable information; but we should like to see incorporated in the book a full account of 12 months' working on the City and Southwark Railway. Of course we must wait for such statistics, but they will be forthcoming for future editions. Meanwhile, as we have said, this edition has been corrected up to date.

"ELECTRIC LIGHT INSTALLATIONS AND THE MANAGEMENT OF ACCUMULATORS," by Sir D. Salomons, Bart.,(Whittaker and Co.), is another new edition—the sixth. Fortunately it is not necessary to criticise the contents of new editions. Good technical books are revised, and editions, like the brook, say "Men may come and men may go, but we go on for ever." This work of Sir D. Salomons is, or should be, a standing warning to literary dry-as-dusts. It is not, it does not pretend to be, an ultra-scientific treatise—it is, and it pretends to be, a simple and graphic account of how to go about the work connected with installations. Commencing as a somewhat meagre pamphlet on accumulators, it has grown, edition after edition, to a bulky volume of over four hundred pages. Its great merit is that it can be "understanded of the multitude." We constantly recommend it as the best book from which to get a good working idea of installation work. The enormous value of Sir D. Salomons's remarks arises from the simple fact that they are mostly the result of experience. Most writers of books argue that so and so will take place if so and so be done. Sir D. Salomons uses the apparatus and gives the result. There is hardly a piece of electrical apparatus of repute but Sir D. Salomons has put it to the test. Various dynamos, motors, engines, measuring instruments, switches, etc., have all been tried, and the results given in this work. For years accumulators have been under constant examination; their excellencies and defects have been studied with great care, as the readers will find. Hardly a practical question, so far as isolated installations, and many connected with central installations, but receive notice and explanation. Once more, then, we commend this book to those who wish for general information.

"ELECTRIC LIGHT: ITS PRODUCTION AND USE," by J. W. Urquhart (Crosby Lockwood and Co.), is another book of a general character. It has reached a fourth edition, has been revised and extended. This compilation must have its uses, as is shown by the successive editions. The author has undoubtedly been energetic in collecting a mass of information, though whether he possesses any skill in arranging that information or in selecting the most useful and rejecting the useless is a matter for discussion. It is evident that a certain number of readers want this kind of stuff, which otherwise cannot be said to commend itself as possessing utility. At the present time the reader has to sift the chaff from the wheat, though were this properly done for him the book would be still more valuable.

"ELECTRICAL INFLUENCE MACHINES," by J. Gray, B.Sc. (Whittaker and Co.), is another book appealing to a different class of readers, yet equally deserving attention. In the rapid extension of the use of electromagnetic apparatus, we often lose sight of electrostatic apparatus. There are certain electrical phenomena, however, that can be best studied by the use of influence machines, and certain measuring instruments constructed upon the principles underlying the phenomena obtained. In Mr. Gray the use and description of these machines have an able exponent. We commend to all young readers a careful and even a prolonged study of Chapter II., upon "A Working Hypothesis of the Electric Field." We think the hypothesis exceedingly ingenious, and one that cannot fail to assist the reader to a better understanding of the phenomena involved. It is of the utmost importance that the student should have a concrete rather than an abstract view of the various phenomena, and Mr. Gray's hypothesis enables him to conceive how it is done. Subsequently the author deals with "electrometers," describing and illustrating the well-known instruments of Sir W. Thomson. This brings us to that part of the book which gives it its title, and here we find an historical *résumé* of the development of such machines, followed by a clear and accurate description of a considerable number of the best-known machines, concluding with instructions how to construct such machines as the Wimshurst, and the Holtz and Voss. The book as a whole is a valuable contribution to electrical literature, dealing as it does with a branch of the subject that, so far as we are aware, has never before received separate treatment.

"ELECTRO-MOTORS — HOW MADE AND HOW USED," by S. R. Bottone (Whittaker).—There are thousands of amateurs and students who possess dexterity in the use of tools, and who like to make all manner of apparatus. In after life this handiwork probably gets placed under a glass case, which is given a position and honoured in the house as the work of "father" when he was young. Mr. Bottone caters for these amateur craftsmen. We merely mention the book. It is not one we can deal with seriously. Whatever the economic values of the machine when constructed, we are certain that the knowledge gained in constructing machines such as described in this book, will be of great value to the worker.

"FIRST PRINCIPLES OF ELECTRICAL ENGINEERING," by C. H. W. Biggs (office of *The Electrical Engineer*), is a book, lengthy extracts from which have appeared in our columns. It is intended for beginners whose object is to join the ranks of the industry, and who have no great desire to know about Thales, or ancient Magnesia, or when the Chinese, or anybody else, discovered the compass, who do not believe that passing the South Kensington examinations to be the height of human felicity and the sure road to scientific renown. It would not become us to blame or praise such a work. The author admits it is imperfect, and promises to remedy some of the defects in future editions—if any are wanted.

We have now to refer to specimens of another class of books—books written for the purposes of the South Kensington Science Examinations. There is perhaps no institution that has had greater power for good or for evil in science teaching than South Kensington. In some directions its syllabus is admirable, in others it is bad beyond all conception. Unfortunately, in the particular branch of science in which we are most interested the syllabus is a delusion and a snare, and a student who follows it has far more trouble to unlearn what he is compelled to learn than he has trouble in learning it. The English language is utterly unable to supply words indicative of the harm the South Kensington examinations have done and are doing so far as matters electrical are concerned. They perpetuate a class of books that have nothing to recommend them except they are prepared according to the syllabus. Intelligent thought there is none, inane experiments there are many, and of questions utterly irrelevant to the tendency of modern thought there is an abundance. Many of the books are bald lists of experiments, fit only to be used as a teacher's or lecturer's notes. Viewed from the one standpoint of enabling students to pass a certain examination, many of these works must be commended; viewed as text-books upon scientific subjects, they are worse than useless—they are misleading.

The following two books are among the best of the South Kensington text-books:

"SOUND, LIGHT, AND HEAT" (Elementary Stage), by J. Spencer (Percival and Co.). "MAGNETISM AND ELECTRICITY" (Elementary Stage), by J. Spencer (Percival and Co.).—The author has evidently gauged the height and depth of the examiner's foibles, and no doubt those who go through these books will pass a good examination with credit to themselves and "payment for results" to the teacher. It has not dawned upon the sapient wiseacres at South Kensington that such questions as, What is Electrolysis? or, What are lightning conductors? are incapable of being answered by the most advanced students yet, the pupils in the elementary stages are supposed to know all about it. When shall we record a change for the better?

THE ENGINES FOR KIDDERPORE INSTALLATION.

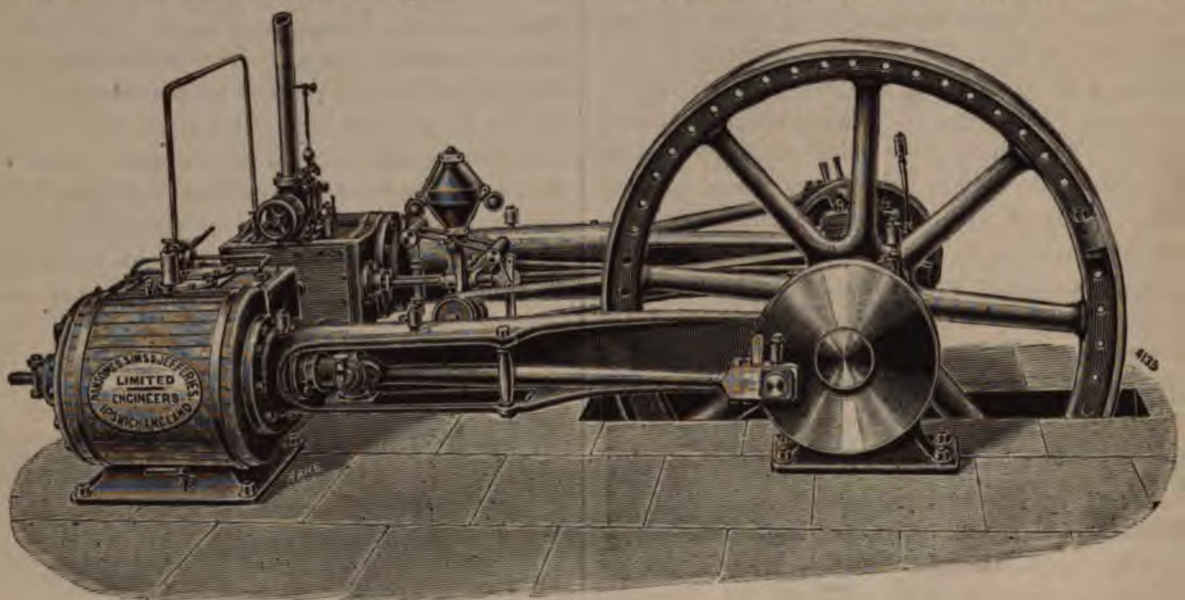
Referring to the general plan and notice of the electric light plant at the Kidderpore Docks, India, which appeared in our issue of the 9th January, we now give, in accordance with our promise, a more detailed description and illustration of Messrs. Ransomes' engines, which furnish the motive power for this installation.

These engines consist of two pairs of the high-pressure long-stroke stationary type, designed and manufactured by Messrs. Ransomes, Sims, and Jefferies.

The engine cylinders are steam jacketed, and also lagged and cased on the outside. The main framing, as will be seen by the drawing, is in one casting, of the hollow girder type, which, while lighter than the ordinary cast-iron foundation plate, is considerably stronger, being in a direct line with the throw or thrust of the engine. The guide-bars are formed by the main frame casting, the guide block being circular and so arranged that the wear may be easily taken up at either top or bottom as required.

A jet condenser of an efficient design is provided to each cylinder, the air pump, which is brass-lined, being worked by an extension of the piston rod through the back cylinder cover. The valves and other parts are well arranged and readily accessible. Special disconnecting valves are supplied so that the engine may be worked with or without a condenser at will.

One of the principal features of the engines is Messrs Ransomes' patent automatic governor expansion gear, which has been used so successfully in connection with electric lighting. In this apparatus an independent gridiron expansion valve, working upon the back of the main slide valve, is operated through a knuckle joint by a link, one end of which is actuated by the cut-off excentric, while the other end is held by a radius rod. The travel of the valve and the point at which it cuts off are governed by the position of the link in relation to the knuckle joint, and this position is varied in accordance with the load on the engine by a powerful and sensitive governor to which the link is connected. By this arrangement the cut-off can be varied between 0 and 70 per cent. of the stroke in proportion to the actual load for the time being on the engine.



Type of Engines at the Kidderpore Installation.

The engines are provided with the necessary feed pumps, and in addition each cylinder is fitted with an improved steam-trap for draining the jacket, and also with a special sight-feed lubricator, the lubrication of the engine being specially arranged for continuous running. The steam for working these engines is to be supplied by two special steel Lancashire boilers, also manufactured by Messrs. Ransomes, Sims, and Jefferies.

INSTITUTION OF CIVIL ENGINEERS.

At the seventh ordinary meeting of the session, on Tuesday, January 13, Sir John Coode, K.C.M.G, president, in the chair, the paper read was on "Auxiliary Engines in connection with the Modern Marine Engine," by Mr. William Henry Allen, A.M.I.C.E.

The paper dealt with the early introduction of auxiliary engines for marine engines, beginning with the year 1870, when the surface condenser was fairly established and the marine engine had assumed the form of the twin compound engine. The author referred to circulating pumps, separate air pumps, fans for forced draught, reversing engines, and electric lighting engines and dynamos.

The following is an abstract of his remarks on the last-mentioned machinery: These were among the latest additions to the engines placed under the care of the sea-going engineer, but they had come into use so rapidly that it was now the practice to fit up cargo steamers, as well as passenger steamers, with them. The difference in the comfort of a ship furnished with electric light, instead of oil lamps, could only be judged by those who had had experience of both. A paper on this subject was read before the institution by Mr. Jamieson, in 1884, since which time considerable advances had been made in perfecting the engine and dynamo for ship work. In the interval, nearly every variety of engine had been tried—turbine, three-cylinder, rotary, single and double acting, open and closed, high and slow speed; but the general opinion appeared to be that the double-acting engine, specially constructed for driving dynamos, was the form which would find the most favour for marine work. At the present time electric light machinery might be classed under two heads—viz., that specially suitable to Admiralty purposes, where the highest economy and efficiency were the principal qualities required; and that appropriate for ordinary merchant steamers, where a good practical engine and dynamo were looked for before economy, except in some of the best Atlantic liners, where combined engines of economical form might be found.

The question of driving dynamos direct from engines or by rope gearing had, the author thought, been settled by the general adoption of the direct-working machine.

The author was of opinion that progress had been largely accelerated by the close specifications issued by the Admiralty, without which latent ability would not have been developed and such great improvements effected in so short a time. The economy of engines and dynamos had been improved, both by increasing the efficiency of the dynamo and by reducing the quantity of water required by the engine itself. Naturally, with a high pressure of steam, combined with the use of the condenser, considerable reduction could be made by way of economy. It would also be seen that these engines had in themselves several advantages over closed engines—namely, accessibility, simplicity, and fair economy, combined with the all-important point of durability. It must not be forgotten that the twin engine with cranks at opposite angles, such as was exclusively used at the Admiralty, had the advantage of working with considerably less vibration than the single-cylinder engine. For the mercantile marine, however, an altogether different type seemed to be preferred. With the exception of some of the largest liners, nearly all vessels were at present being fitted with single-cylinder direct-acting engines and dynamos, the object of the owners being to secure a machine which should run constantly without repair or breakdown, and one which could be readily understood by ordinary marine engineers, and repaired by them when necessary.

The ship-lighting dynamo had been greatly improved during the last year or so, and the drum-wound armature machine was one which had been found to work satisfactorily. The armature consisted of a cast-iron hub mounted on a steel spindle, having laminated plates for the core, the whole being drum-wound on the outside. Every part at all likely to get out of order was visible, and could be readily repaired by those in charge of the machine. The voltage at which the author had found it most convenient to work in merchant ships was 60 volts, which was suitable for glow lamps as well as for projectors.

Bearing in mind that the electric light engine had generally to work harder and longer than any other in the ship, the light being required both when in port and at sea, the matter of economy was of some importance. The efficiency of ordinary ship-lighting dynamos, such as those which had been constructed by the author with double-acting engines, was in some cases as high as 83 per cent.

DUBLIN LIGHTING.

The question of Dublin lighting was not settled at the time of going to press. From the telegrams of our correspondent we gather that the question has been discussed in committee for two or three days, and was adjourned yesterday till to-day (Friday).

The tenders amount to 18, and, according to the advertisement inviting them, "the parties tendering shall be bound to build station, supply, erect, and fix all necessary plant, machinery, engines, boilers, dynamos, conductors, pillars, etc." In response, the following proposals were received, these being opened on 1st November last:

Westinghouse Electric Co.	£52,000	£55,350, reducible to £51,000
Hornsby and Sons	29,904	
Sharp and Kent	—	Partial only
Johnson and Phillips	30,639	
Edmundson and Co.	39,117	
Laing, Wharton, and Down	27,090	
Electrical Engineering Co. of Ireland	29,338	Alternative, £29,825
Irish House-to-House Electrical Co.	37,000	
Woodhouse and Rawson	38,103	
Crompton and Co.	31,354	Alternative, £28,971
Electric Construction Co.	—	Partial only
Ryan and Purcell	23,448	With extras would be £24,472, exclusive of buildings
J. E. H. Gordon and Co.	38,500	
Babcock and Wilcox	5,003	Boilers only
W. T. Goolden and Co.	—	Partial only
Siemens Bros. and Co.	—	Partial only
Latimer Clark, Muirhead, and Co.	21,283	Exclusive of buildings
Drake and Gorham	—	Partial only

These tenders were referred by the Special Committee having the electric lighting in charge to the borough surveyor (Mr. Spencer Harty), and to Mr. Manville, electrical engineer, for analysis and report, and in due course these gentlemen presented their report, in which, among other things, they state—

"The lowest complete tender, without buildings, for plant by a responsible maker is that of Messrs. Hornsby and Sons, for Johnson and Phillips's electrical machinery, and their own engines, with Babcock and Wilcox boilers. Their price, amounting to £25,178, is apparently arrived at by the low cost of the meters, of which no particulars are given; of the main laying, which is on a system not seen in operation by you when inspecting various systems; and by dynamos which have revolving armatures instead of stationary armatures.

"On the whole, we are inclined to think that the work proposed by this firm would not be of as perfect a nature as that proposed by some of the other contractors. The complete tender of the Electrical Engineering Company of Ireland, inclusive of the dearest engines of the three types named by them, and amounting to £28,907, without building, is, perhaps, the most complete total tender, at a moderate price; but in the event of your deciding to accept this tender for all sections, you will notice that we have previously recommended that they be asked to reconsider their system of main laying. The tender of the Irish House-to-House Company is equally satisfactory and complete as the last mentioned, with the exception of their price for the engines and sundries, which are tendered for at an abnormally high price, and if their price under this specification were reduced to the same level as that of the other contractors, their total cost would be nearly exactly the same as that of the Electrical Engineering Company of Ireland—still, of course, excluding buildings.

"A good arrangement with two contractors might be made by selecting the Electrical Engineering Company of Ireland for the engines, boilers, and the public lighting plant, amounting to £16,033, and the Irish House-to-House Company for the alternators, regulating apparatus, transformers, meters, and cables, amounting to £15,244, and making together a total of £31,277, without buildings; and in this case the responsibilities of the two contractors will not in any way intermingle, and the Corporation will have the benefit of the system of main laying proposed by the Irish House-to-House Company, and which meets with our entire approval; or, perhaps, a still better arrangement would be made by dividing the work between three contractors—the Electrical Engineering Company of Ireland, as before, for the engines, boilers, and public lighting plant, amounting to £16,033, and the Irish House-to-House Company for the mains, amounting to £4,578, and Messrs. J. E. H. Gordon and Co., for the alternators, regulating apparatus, transformers and meters, amounting to £8,096, or a total of £28,707. Messrs. Gordon and Co. quote for identically the same dynamos, transformers, and meters as the Irish House-to-House Company, and more than probably by the same makers, and, therefore, you will be getting, by this combination, the same plant for £28,707, as included in the total of £31,277, in combination of the Electrical Engineering Company of Ireland and the Irish House-to-House Company. Assuming that you were to accept the tenders last mentioned, there would still be an amount of £4,000 to be added for the buildings, and a sum of £3,000 for sub-transformer stations, as recommended by some of the contractors, and endorsed by us, making a grand total of £35,707 to put the system in complete working order, and leaving the sum of £1,293 for sundry expenses and contingencies to bring the sum up to £37,000, originally estimated by us. If the Electrical Engineering Company of Ireland's tender were accepted, the grand total would amount to £35,907, without contingencies; and if the second proposition, as above, were carried out, the grand total would be £38,277, without contingencies."

Mr. Manville in his appendix to the city engineer's report says: "The specifications are for two schemes—one on the assumption that a central station is put down with sufficient plant to provide current for 80 arc lamps of about 1,000 c.p. each, and 3,000 incandescent lamps of 16 c.p. each; the other on the assumption that power is provided for the same number of arc lamps for the public lighting, but with sufficient power and enlarged mains for the supply of current to 5,000 lamps of 16 c.p. each for the private lighting. The number of lamps and their arrangement allowed for the public lighting is, in my opinion, amply sufficient for the perfect illumination of those streets, and sufficient amount of spare plant is allowed to effectually guard against chances of a breakdown. The circuits are so arranged that each alternate lamp is on a different circuit, and the temporary extinction of one circuit would not interfere with the public convenience. Allowing that on an average 10 per cent. of the 3,000 lamps are burning day and night, 129,600 Board of Trade units will be sold on this account; and that the balance of the 3,000 lamps are burning on an average 1,000 hours per annum, 162,000 Board of Trade units will be sold on this account; or, together, 291,000 Board of Trade units; that at 7d. per unit will yield a gross revenue of £8,487. 10s., from which the annual maintenance charges of £6,262 have to be deducted, leaving a net revenue of £2,221. Allowing that on an average 10 per cent. of the 5,000 lamps are burning day and night, 180,000 Board of Trade units will be sold on private account; and that the whole of the 5,000 lamps are burning on an average 1,000 hours per annum, 300,000 Board of Trade units will be sold on this account; or together, 480,000 Board of Trade units; that at 7d. per unit will yield a gross revenue of £14,000, from which the annual maintenance charge of £7,915 has to be deducted, leaving a net revenue of £7,085. The cost of the arc lighting—viz., £1,600—must be added to this, making the real net revenue £8,685. The approximation of the revenue depends upon the actual amount of light that will be consumed."

EXHIBITIONS.

BY SYDNEY F. WALKER.

It is devoutly to be hoped that the result of the recent exhibition at Edinburgh, with its heavy call upon the guarantors, and the incident of the gross indignity stated to have been offered to its manager, will have the effect of damping the ardour of would-be exhibition-mongers. To the man of business, with few exceptions, exhibitions are an expense and an unmitigated nuisance. He has to pay for space in which to place his exhibit, for constructing his stall, usually for steam power if he requires it, for an attendant to be always on hand to explain his exhibit to a chance passer-by, possibly an employé of a rival firm. He has to lock up a large quantity of stock, whatever it may be, for months together; and often, in the case of electrical exhibits, at the time of the year when he has the best chance of selling them. To crown all, if he is not in constant attendance, say if the exhibition is held in a different part of the country from where his works are situate, he has to pay to go into the exhibition to see his own exhibit. At the Newcastle Exhibition, for instance, the writer, whose firm had a stall there, when spending a few days in the town, wrote to the exhibition committee asking for a pass, and was refused. The executive secretary replied that the writer might have a ticket for 15s., the usual daily entrance fee being 1s. But the exhibitor's troubles are not ended even yet. He is hampered at every step. His stall must not be above a certain height; must not contain this or that. He must not do this or that without the consent of the committee, and as a climax he takes all the risk, so far as his stall is concerned, of fire, water, or any damage to his goods of any kind; though, by the arrangements made, he is absolutely in the hands of the officials as to his security from damage from any of the above causes. He is afforded no protection from theft, for instance.

Then as to his stall. He must be thankful to get this wherever an omnipotent committee may place him. He may have arranged for a stall of a certain size, and have got all his fittings ready, and suddenly be informed that he can only have half the space he has applied for. If his stall is poked away in some corner where no one is likely to pass, unless it be a straggler who has lost his way in the labyrinth usually presented by these exhibitions, so that all the expense he has incurred will be practically thrown away, even under the most favourable circumstances, there is no redress. The omnipotent committee has got his money, and will keep it. He may grin and bear it as best he can. And even the above do not represent all the troubles of the exhibitor. His apparatus is open to the inspection of all his rivals. Unless his particular specialities are either very carefully protected by a patent, and the £10,000 necessary in these days to support a patent, or are of so little use to anyone as not to be worth the trouble, he will assuredly have them copied. Further, if he exhibits any apparatus in work every chance slip or breakdown is noted to his disadvantage, even by the very men whom his exhibit is intended to benefit. But the cream of the whole thing is that in nearly all the exhibitions that have been held of late years the vast majority of the public do not go to see the exhibits at all. There may be an odd thing or two of startling novelty, such as the phonograph, that they will crowd to see and hear; but as a rule they go to hear the band, see their friends, the beautiful display of lights, of the illuminated fountains, and so on. It was delightful, for instance, during the Manchester and Glasgow Exhibitions after the day's work was done to take the train out to the exhibition, enjoy an *al fresco* tea under the trees, listening the while to the strains of the really excellent bands that were provided, see the fountains play later on, and then go back to one's hotel to bed. It was much better than sitting in the hotel all the evening, or going to a stuffy theatre, or even walking about the streets. And all this was provided for the modest charge of one shilling, a really good tea being provided for another shilling. From the point of view of the general public this sort of thing is charming. From that of the exhibitor, who pays for it all and usually gets very little in return, it is the reverse of charming.

It is hardly pleasant to an exhibitor who has gone to great expense to find the public who he is entertaining, in the hope that they will pay him in kind, deserting his stall for the greater attractions in the grounds. But the general public, after all, is not so very much to blame. Looking at exhibits which one does understand is very tiring if carried on for long. Looking at those one does not know the A B C of is positive hard work if it is done conscientiously; and an awful bore if it is not. The music, the grounds, the Turkish cafés, and all the lighter attractions are thrown in to disguise the solid matter inside the building, just as the spoonful of jam was used to disguise the nauseous but wholesome powder we used some of us to be forced to take in our young days. That great overgrown child, the British public, would not come twice if it was all solid meat. He must have a few lighter things thrown in, which he takes very kindly to—at the expense of that willing horse, the exhibitor.

The writer has met men, too, rare birds, who have told him that exhibitions paid them. He is strongly inclined to believe, though, that they were dazzled by a few orders and had not counted all the cost; further, there are cases where it is quite possible to make an exhibition pay even an exhibitor. If you can have a handsome showcase made, taking very small floor space, but able to contain samples of all the apparatus you make, and requiring no attendance, not even dusting, then you may possibly get a return for your outlay. The additional cost for each exhibition after the first outlay being very trifling, almost any orders you get will repay you, provided the value of the apparatus locked up in the case is not too great, and that you sustain no damage from fire, water, mischief, etc. But you can get all this at any railway station without going to the trouble of building an exhibition for it; and you will be far more certain of an appreciative public. To a traveller waiting for a train at a railway station everything is an attraction that will pass away the time, while there are no sweet strains of delightful bands in the vicinity to distract the attention.

There is also another case where exhibitions may pay the exhibitor. If a firm or company be newly started, with a new thing which it is important should be placed before the public, large numbers of them, quickly, then the exhibition stands unrivalled. In fact, with companies having the capital, the plan would be to have an exhibition, gardens, illuminated fountains, and all the paraphernalia, all to themselves. There would be a far greater chance of a remunerative return than in taking a stall in someone else's exhibition. When a visitor could not move, or look, or speak without being reminded of the presence of John Jones and Co., he could not help being impressed with the fact that John Jones and Co. were very much in existence, and that enterprising firm would have accomplished the great object of all advertising—viz., bringing their living presence home to the buyer.

The writer has heard men of business who had no particular novelty to bring forward say that exhibitions have paid them. He believes that they are mistaken; that if they had expended the amount which their exhibit cost them in other methods of advertising they would have secured a far greater return. It is possible that in many cases an unexpected source of business has been tapped through an exhibition that would not have occurred to the exhibitor to seek after, but the cases where this occur are few, and probably a more careful and diligent use of the ordinary resources of advertising would have done it equally as well, if possibly a little later.

Another point that should not be overlooked in connection with this matter, and which forms a large part of the difficulty of securing a profitable return for the outlay, is the almost invariably expensive management of the whole affair. Business men have rarely anything to do with exhibitions beyond their own exhibits. It is nearly always left entirely to men who have no business experience, and though the result is more often satisfactory from the engineer's point of view—all goes off well—than one would expect, it is nearly always attained at a much higher cost than would be necessary under ordinary commercial conditions, and that notwithstanding that apparently every possible source of income is utilised to the very utmost. The poor exhibitor is bled as long as he will stand it, under every conceivable disguise. But what ought to be a handsome surplus is dribbled away in petty expenses, and in other ways that the ordinary man of business is always on the look-out for Even when there is a surplus, with no declared object in view no thought of the exhibitor is taken. No one thinks of helping him with his expenses. The surplus is left somewhere in a bank for lawyers to fight over.

Further, the temporary nature of the structure and all connected with the exhibition, necessarily renders it a very expensive method of placing almost anything before the public. Exhibition buildings must be substantially put up—usually to be pulled down in six months at latest, and the old materials sold. Grounds must be made temporarily decorative in some parts, while in others considerable damage is done which has to be made good. And all this—all the salaries, all the waste, all the amusement, everything, in fact—comes out of the exhibitor's pocket, while he is very lucky indeed if he gets a return—in profit on orders taken directly or indirectly—of small percentage of his outlay.

THE ELECTROMAGNET.*

. BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E

(*Concluded from page 77.*)

Such little motors are often now used for spinning Geissler's vacuum tubes. In these motors the iron rim is fixed, and the electromagnet rotates. The pole of the electromagnet finds itself a certain distance away from the iron ring, it tries to get nearer. The only way it can get nearer is by swinging round, and so it gradually approaches, and as it approaches the place where it is nearest to the internal projection of the rim the current is cut off, and it swings further. This mode may be likened to a cam in a mechanical movement. It is, in fact, nothing else than an electromagnetic cam. There are other devices too, which are more like electromagnetic linkages. If you curve the poles or shape them out you may obtain actions which are like that of a wedge on an inclined plane. There is an electromagnet in one of Paterson and Cooper's arc lamps wherein the pole-piece, coming out below the magnet, has a very peculiar shape, and the armature is so pivoted with respect to the magnet, that as the armature approaches the core as a whole its surface recedes from that of the pole-piece, the effect being that the pull is equalised over a considerable range of motion. There is a somewhat similar device in De Puydt's pattern of arc lamp.

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* Cantor lectures, delivered before the Society of Arts.

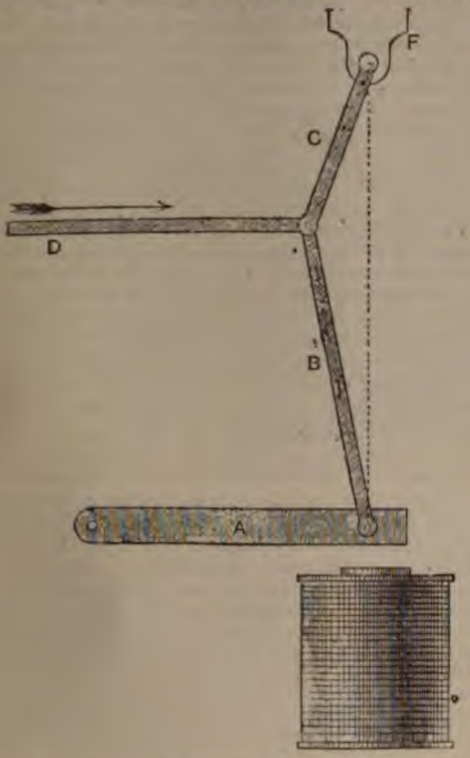

Fig. 68.—Froment's Equaliser with Stanhope Lever.

Here is another device for oblique approach, made by Froment. In the gap in the circuit of the magnet a sort of iron wedge is put in, which is not attracted squarely to either face, but comes in laterally between guides. Another of Froment's equalisers, or distributors, consists of a parallel motion attachment for the armature, so that oblique approach may take place without actual contact. Here, Fig. 68, is another mechanical method of equalising devised by Froment, and used by Le Roux. You know the Stanhope lever, the object of which is to transform a weak force along a considerable range into a powerful force of short range. Here we use it backwards. The armature itself, which is attracted with a powerful force of short range, is attached to the lower end of the Stanhope lever, and the arm attached to the knee of the lever will deliver a distributed force over quite a different range. One way, not of equalising the actual motion over the range but of counterbalancing the variable attractive force, is to employ a spring instead of gravity to control the armature. So far back as 1838, Edward Davy, in one of his telegraphic patents, described the use of a spring, Fig. 69, to hold back the armature. Davy preceded Morse in the use of a spring to pull back the armature. There is a way of making a spring act against an armature more stiffly as the pull gets greater. In this method there is a spring with various set screws set up against it, and which come into action at different ranges, so as to alter the stiffness of the spring, making it virtually stiffer as the armature approaches the poles. Yet another method is to employ, as the famous conjuror Robert Houdin did, a rocking lever. Fig. 70 depicts one of Robert Houdin's equalisers. The pull of the electromagnet on the armature acts on a curved lever which works against a second one; the point of application of force between the one and the other altering with their position. When the armature is far away from the pole, the leverage of the first lever on the second lever is great. When the armature gets near, the leverage of the first lever on the second is comparatively small. This employment of the rocking lever was adopted from Houdin by Duboscq, and put into the Duboscq arc lamp, where the regulating mechanism at the bottom of the lamp contains a rocking lever. Here, upon the lecture table, is a Duboscq's arc lamp. In this pattern, Fig. 71, one lever, B, which is curved, plays against another, A, which is straight. A similar mechanism is used for equalising the action in the Serrin arc lamp, where one of the springs that holds up the jointed parallelogram frame is applied at the end of a rocking lever to equalise the pull of the regulating electromagnet. In this lamp there is also introduced the principle of oblique approach; for the armature of the electromagnet is not allowed to travel straight towards the poles of the magnet, but is pulled up obliquely past it.

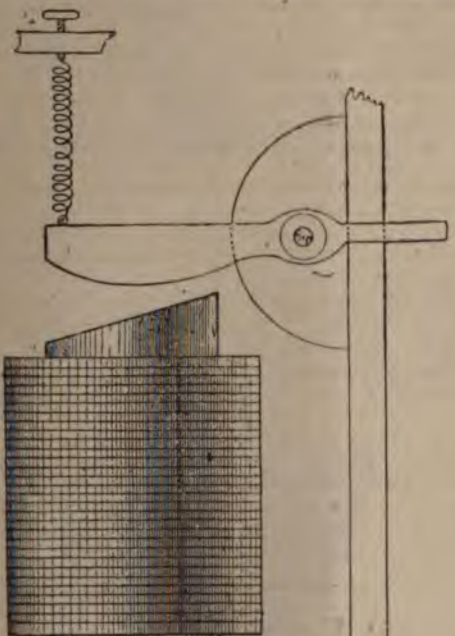

Fig. 69.—Davy's Mode of Controlling Armature by Spring.

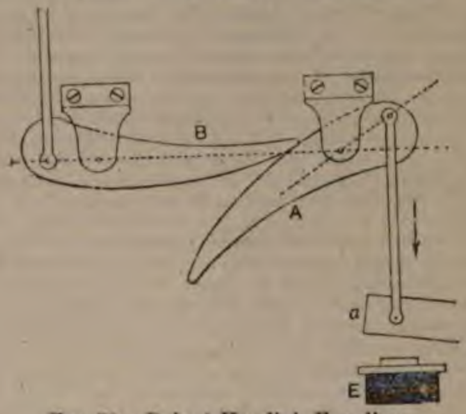

Fig. 70.—Robert Houdin's Equaliser.

Another device for equalising the pull was used by Wheatstone in his step-by-step telegraph in 1840. A hole is pierced in the armature, and the end of the core is formed into a projecting cone, which passes through the aperture of the armature, thereby securing a more equable force and a longer range. The same device has reappeared in recent years in the form of electromagnet used in the Thomson-Houston arc lamp, and in the automatic regulator of the same firm.

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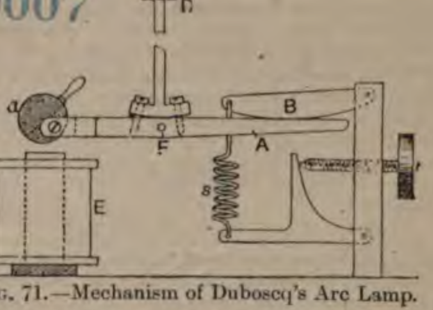

Fig. 71.—Mechanism of Duboscq's Arc Lamp.

POLARISED MECHANISM: USES OF PERMANENT MAGNETS.

We must now turn our attention to one class of electromagnetic mechanism which ought to be carefully distinguished from the rest. It is that class in which, in addition to the ordinary electromagnet, a permanent magnet is employed. Such an arrangement is generally referred to as a polarised mechanism. The objects for which the permanent magnet is introduced into the mechanism appear to be in different cases quite different. I am not sure whether this is clearly recognised, or whether a clear distinction has even been drawn between three entirely separate purposes in the use of a permanent magnet in combination with an electromagnet. The first purpose is to secure unidirectionality of motion, the second is to increase the rapidity of action and of sensitiveness to small

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currents, the third to augment the mechanical action of the current.

(*a*.) *Unidirectionality of Motion.*—In an ordinary electromagnet it does not matter which way the current circulates. No matter whether the pole is north or south, the armature is pulled, and on reversing the current the armature is also pulled. There is a rather curious old experiment which Sturgeon and Henry showed, that if you have an electromagnet with a big weight hanging on it, and you suddenly reverse the current, you reverse the magnetism, but it still holds the weight up ; it does not drop. It has not time to drop before the magnet is charged up again with magnetic lines the other way on. Whichever way the magnetism traverses the ordinary soft iron electromagnet the armature is pulled. But if the armature is itself a permanent magnet of steel, it will be pulled when the poles are of one sort, and pushed when the poles are reversed—that is to say, by employing a polarised armature you can secure unidirectionality of motion in correspondence with the current. One immediate application of this fact for telegraphic purposes is that of duplex telegraphy. You can send two messages at the same time and in the same direction to two different sets of instruments, one set having ordinary electromagnets, with a spring behind the armature of soft iron, which will act simply independently of the direction of the current, depending only on its strength and duration ; and another set having electromagnets with polarised armatures, which will be affected not by the strength of the current, but by the direction of it. Accordingly, two completely different sets of messages may be sent through that line in the same direction at the same time.

Another mode of constructing a polarised device is to attach the cores of the electromagnet to a steel magnet, which imparts to them an initial magnetisation. Such initially-magnetised electromagnets were used by Brett in 1848, and by Hjörth in 1850. A patent for a similar device was applied for in 1870 by Sir William Thomson, and refused by the Patent Office. In 1871, S. A. Varley patented an electromagnet having a core of steel wires united at their ends.

Wheatstone used a polarised apparatus consisting of an electromagnet acting on a magnetised needle. He patented, in fact, in 1845, the use of a needle permanently magnetised to be attracted one way or the other between the poles of an electromagnet. Sturgeon had described the very same device in the *Annals of Electricity* in 1840. Gloesner claims to have invented the substitution of permanent magnets for mere armatures in 1842. In using polarised apparatus it is necessary to work, not with a simple current that is turned off and on, but with reversed currents. Sending a current one way will make the moving part move in one direction, reversing the current makes it go over to the other side. The mechanism of that particular kind of electric bell that is used with magneto-electric calling apparatus furnishes an excellent example of a polarised construction. With these bells no battery is used, but there is a little alternate-current dynamo, worked by a crank. The alternate currents cause the pivoted armature in the bell to oscillate to right and left alternately, and so throw the little hammer to and fro between the two bells.

(*b*.) *Rapidity and Sensitiveness of Action.*—For relay work polarised relays are often employed, and have been for many years. Here on the table is one of the Post Office pattern of standard relay, having a steel magnet to give magnetism permanently to a little tongue or armature which moves between the poles of an electromagnet that does the work of receiving the signals. In this particular case the tongue of polarised relay works between two stops, and the range of motion is made very small in order that the apparatus may respond to very small currents. At first sight it is not very apparent why putting a permanent magnet into a thing should make it any more sensitive. Why should permanent magnetism secure rapidity of working? Without knowing anything more, inventors will tell you that the presence of a permanent magnet increases the rapidity with which it will work. You might suppose that permanent magnetism is something to be avoided in the cores of your working electromagnets, otherwise the armatures would remain stuck to the poles when once they had been attracted up. Residual magnetism would, indeed, hinder the working unless you have so arranged matters that it shall be actually helpful to you. Now for many years it was supposed that permanent magnetism in the electromagnet was anything but a source of help. It was supposed to be an unmitigated nuisance, to be got rid of by all available means, until, in 1855, Hughes showed us how very advantageous it was to have permanent magnetism in the cores of the electromagnet. Here, Fig. 51, is the drawing of Hughes's magnet to which I referred in Lecture III. A compound permanent magnet of horseshoe shape is provided with coils on its pole-pieces, and there is a short armature on the top attached to a pivoted lever and a counteracting spring. The function of this arrangement is as follows. That spring is so set as to tend to detach the armature, but the permanent magnet has just enough magnetism to hold the armature on. You can, by screwing up a little screw behind the spring, adjust these two contending forces, so that they are in the nicest possible balance ; the armature held on by the magnetism, and the spring just not able to pull it off. If, now, when these two actions are so nearly balanced you send an electric current round the coils, if the electric current goes one way round it just weakens the magnetism enough for the spring to gain the victory, and up goes the armature. This apparatus then acts by letting the armature off when the balance is upset by the electric current ; and it is capable of responding to extremely small currents. Of course, the armature has to be put on again mechanically, and in Hughes's type-writing telegraph instruments it is put on mechanically between each signal and the next following one. The arrangement constitutes a distinctive piece of electromagnetic mechanism.

(*c*.) *Augmenting Mechanical Action of Current.*—The third purpose of a permanent magnet to secure a greater mechanical action of the varying current is closely bound up with the preceding purpose of securing sensitiveness of action. It is for this purpose that it is used in telephone receivers ; it increases the mechanical action of the current, and therefore makes the receiver more sensitive. For a long time this was not at all clear to me ; indeed, I made experiments to see how far it was due to any variation in the magnetic permeability of iron at different stages of magnetisation, for I found that this had something to do with it, but I was quite sure it was not all. Prof. George Forbes gave me the clue to the true explanation ; it lies in the law of traction with which you are now familiar, that the pull between a magnet and its armature is proportional to the square of the number of magnetic lines that come into action. If we take N, the number of magnetic lines that are acting through a given area, then to the square of that the pull will be proportional. If we have a certain number of lines, N, coming permanently to the armature, the pull is proportional to N^2. Suppose the magnetism now to be altered—say, made a little more, and the increment be called $d\,\mathsf{N}$; so that the whole number is now $\mathsf{N}+d\,\mathsf{N}$. The pull will now be proportional to the square of that quantity. It is evident that the motion will be proportional to the difference between the former pull and the latter pull. So we will write out the square of $\mathsf{N}+d\,\mathsf{N}$, and the square of N, and take the difference.

$$\begin{array}{ll} \text{Increased pull, proportional to......} & \mathsf{N}^2+2\,\mathsf{N}\cdot d\,\mathsf{N}+d\,\mathsf{N}^2\;; \\ \text{Initial pull, proportional to .. ..} & \mathsf{N}^2 \qquad\qquad\qquad\;\; ; \\ \cline{2-2} \text{Subtracting ; difference is ......} & 2\,\mathsf{N}\cdot d\,\mathsf{N}+d\,\mathsf{N}^2. \end{array}$$

We may neglect the last term, as it is small compared with the other. So we have, finally, that the change of pull is proportional to $2\,\mathsf{N}\cdot d\,\mathsf{N}$. The alteration of pull between the initial magnetism and the initial magnetism with the additional magnetism we have given to it, turns out to be proportional, not simply to the change of magnetism, but also to the initial number N that goes through it to begin with. The more powerful the pull to begin with, the greater is the change of pull when you produce a small change in the number of magnetic lines. That is why you have this greater sensitiveness of action when using Hughes's electromagnets, and greater mechanical effect as the result of applying permanent magnetism to the electromagnets of to telephone receivers.

ELECTROMAGNETIC MECHANISM.

There are some other kinds of electromagnetic mechanism to which I must briefly invite your attention, as forming an important part of this great subject. Of one of these the mention of permanent magnets reminds me.

MOVING COIL IN PERMANENT MAGNETIC FIELD.

A coil traversed by an electric current experiences mechanical forces if it lies in a magnetic field ; the force being proportional to the intensity of the field. Of this principle the mechanism of Sir W. Thomson's syphon recorder is a well-known example. Also those galvanometers which have for their essential part a movable coil suspended between the poles of a permanent magnet, of which the earliest example is that of Robertson (see *Encyclopædia Britannica*, ed. viii., 1855), and of which Maxwell's suggestion, afterwards realised by D'Arsonval, is the most modern. Siemens has constructed a relay on a similar plan.

MAGNETIC ADHERENCE.

There are a few curious pieces of apparatus devised for increasing adherence electromagnetically between two things. Here is an old device of Nicklès, who thought he would make a new kind of rolling gear. Whether it was a railway wheel on a line, or whether it was going to be an ordinary wheel gearing, communication of motion was to be made from one wheel to another, not by cogs or by the mere adherence of ordinary friction, but by magnetic adherence. In Fig. 72 there are shown two iron wheels

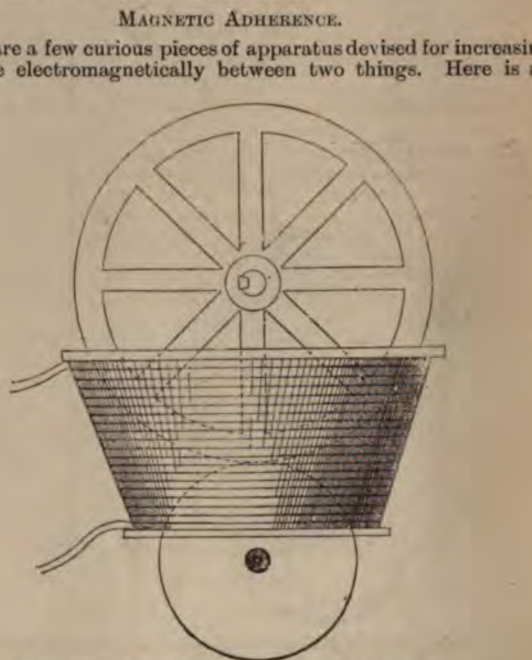

FIG. 72.—Nicklès's Magnetic Friction Gear.

rolling on one another, with a sort of electromagnetic jacket around them, consisting of an electric current circulating in a coil, and causing them to attract one another and stick together with magnetic adherence. In Nicklès's little book on the subject there are a great number of devices of this kind described, including a magnetic brake for braking railway waggons, engines, and carriages, applying electromagnets either to the wheels or else to the line, to stop the motion whenever desired. The notion of using an electromagnetic brake has been revived quite recently in a much better form by Prof. G. Forbes and Mr. Timmis, whose particular form of electromagnet, shown in Fig. 73, is peculiarly interesting, being a better design than any I have ever seen for securing powerful magnetic traction for a given weight of iron and copper. The magnet is a peculiar one ; it is represented here as cut away to show the internal construction. There is a sort of horseshoe made of one grooved rim, the whole circle of coil being laid embedded in the groove. The armature is a ring which is attracted down all round, so that you have an extremely compact magnetic circuit around the copper wire at every point. The magnet part is attached to the frame of the waggon or carriage, and the ring armature is attached to the wheel or to its axis. On switching on the electric current the rim is powerfully pulled, and braked against the polar surface of the electromagnet.

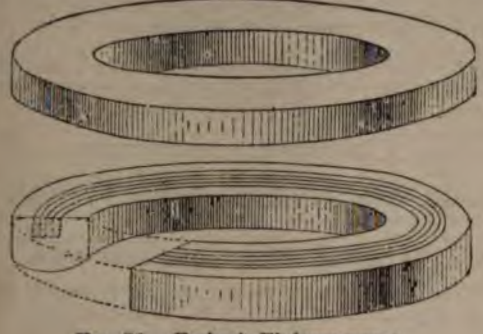

FIG. 73.—Forbes's Electromagnet.

Forbes's arrangement appears to be certainly the best yet thought of for applying a magnetic brake to the wheels of a railway train.

Another, but quite distinct, piece of mechanism depending on electromagnetic adherence is the magnetic clutch employed in Gülcher's arc lamp.

Repulsion Mechanism.

Then there are a few pieces of mechanism which depend on repulsion. In 1850 a little device was patented by Brown and Williams, consisting, as shown in Fig. 74 of an electromagnet which repelled part of itself. The coil is simply wound on a hollow tube, and inside the coil is a piece, B, of iron, bent as the segment of a cylinder to fit in, going from one end to the other. Another little iron piece, A, also shaped as the segment of a tube, is pivoted in the axis of the coil. When these are magnetised one tends to move away from the other, they being both of the same polarity. Of late there have been many ampere-meters and voltmeters made on this plan of producing repulsion between the parallel cores.

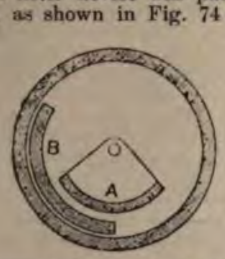

FIG. 74.—Electromagnetic Mechanism Working by Repulsion.

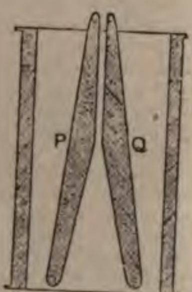

FIG. 75.—Repulsion between Two Parallel Cores.

Here, Fig. 75, is another device of recent date, due to Maikoff and De Kabath. Two cores of iron, not quite parallel, pivoted at the bottom, pass up through a tubular coil. When both are magnetised, instead of attracting one another they open out ; they tend to set themselves along the magnetic lines through that tube. The cores being wide open at the bottom tend to open also at the top.

Electromagnetic Vibrators.

Then there is a large class of mechanisms about which a whole chapter might be written—namely, those in which vibration is maintained electromagnetically. The armature of an electromagnet is caused to approach and recede alternately with a vibrating motion, the current being automatically cut off and turned on again by a self-acting brake. The electromagnetic vibrator is one of the cleverest things ever devised. The first vibrating electromagnetic mechanism ever made was exhibited here in this room in 1824 by its inventor, an Englishman named James Marsh. It consisted of a pendulum vibrating automatically between the poles of a permanent magnet. Later, a number of other vibrating devices were produced by Wagner, Neef, Froment, and others. Most important of all is the mechanism of the common electric trembling bell, invented by a man whose very name appears to be quite forgotten—John Mirand. How many of the millions of people who use electric bells know the name of the man who invented it? John Mirand, in the year 1850, put the electric bell practically into the same form in which it has been employed from that day to this. The vibrating hammer, the familiar push-button, the indicator, or annunciator, are all of his devising, and may be seen depicted in the specification of his British patent just as they came from his hand.

Time alone precludes me from dealing minutely with these vibrators, and particularly with the recent work of Mercadier and that of Langdon-Davies, whose researches have put a new aspect on the possibilities of harmonic telegraphy. Langdon-Davies's rate-governor is the most recent and perfect form of electromagnetic vibrator.

Indicator Movements.

Upon the table here are a number of patterns of electric bells, and a number also of the electro-mechanical movements or devices employed in electric bell work, some of which form admirable illustrations of the various principles that I have been laying down. Here is an iron-clad electromagnet ; here a tripolar magnet ; here a series of pendulum motions of various kinds ; here is an example of oblique pull ; here is Jensen's indicator, with lateral pull ; here is Moseley's indicator, with a coil and plunger, iron-clad ; here is a clever device in which a disc is drawn up to better the magnetic circuit. Here, again, is Thorpe's semaphore indicator, one of the neatest little pieces of apparatus, with a single central core surrounded by a coil, while a little strip of iron coming round from behind serves to complete the circuit all save a little gap. Over the gap stands that which is to be attracted, a flat disc of iron, which, when it is attracted, unlatches another disc of brass which forthwith falls down. It is an extremely effective, very sensitive, and very inexpensive form of annunciator. The next two are pieces of polarised mechanism having a motion directed to one side or the other, according to the direction of the current. From the back-board projects a small straight electromagnet. Over it is pivoted a small arched steel magnet, permanently magnetised, to which is attached a small signal lever bearing a red disc. If there is a current flowing one way then the magnet that straddles over the pole of the electromagnet will be drawn over in one direction. If I now reverse the current, the electromagnet attracts the other pole of the curved magnet. Hence this mechanism allows of an electrical replacement, without compelling the attendant to walk up to the indicator board. The polarised apparatus for indicators has this advantage, that you can have electrical as distinguished from mechanical replacement.

The Study of Electromagnetic Mechanism.

The rapid survey of electromagnetic mechanisms in general has necessarily been very hurried and imperfect. The study of it is just as important to the electrical engineer as is the study of mechanical mechanism to the mechanical engineer. Incomplete as is the present treatment of the subject, it may sufficiently indicate to other workers useful lines of progress, and so fitly be appended to these lectures on the electromagnet. In a very few years we may expect the introduction into all large engineering shops of electromagnetic tools. On a small scale, for driving dental appliances, electromagnetic engines have long been used. Large machine tools, electromagnetically worked, have already begun to make their appearance. Some such were shown at the Crystal Palace in 1881, by Mr. Latimer Clark, and more recently, Mr. Rowan, of Glasgow, has devised a number of more developed forms of electromagnetic tools.

Suppression of Sparking.

It now remains for me to speak briefly of the suppression of sparks. There are some half-dozen different ways of trying to get rid of the sparking that occurs in the breaking of an electric circuit whenever there are electromagnets in that circuit. Many attempts have been made to try and get rid of this evil. For instance, one inventor employs an air blast to blow out the spark just at the moment it occurs. Another causes the spark to occur under a liquid. Another wipes it out with a brush of asbestos cloth that comes immediately behind the wire and rubs out the spark. Another puts on a condenser to try and store up the energy. Another tries to put on a long thin wire or a high resistance of liquid, or something of that kind, to provide an alternate path for the spark, instead of jumping across the air and burning the contacts. There exist some half-score, at any rate, of that kind of device. But there are devices that I have thought it worth while to examine and experiment upon, because they depend merely upon the mode of construction adopted in the building of the electromagnet, and they have each their own qualities. I have here five straight electromagnets, all wound on bobbins the same size, for which we shall use the same iron core and the same current for all. They are all made, not only with bobbins of the same size, but their coils consist as nearly as possible of the same weight of wire. The first one is wound in the ordinary way; the second one has a sheath of copper wound round the interior of the bobbin before any wire is put on. This was a device, I believe, of the late Mr. C. F. Varley, and is also used in the field magnets of Brush dynamos. The function of the copper sheath is to allow induced currents to occur, which will retard the fall of magnetism, and damp down the tendency to spark. The third one is an attempt to carry out that principle still further. This is due to an American of the name of Paine, and has been revived of late years by Dr. Aron, of Berlin. After winding each layer of the coil a sheath of metal foil is interposed so as to kill the induction from layer to layer. The fourth one is the best device hitherto used—namely, that of differential winding, having two coils connected so that the current goes opposite ways. When equal currents flow in both circuits there is no magnetism. If you break the circuit of either of the two wires the core at once becomes magnetised. You get magnetism on breaking, you destroy magnetism on making the circuit. It is just the inverse case to that of the ordinary electromagnet. There the spark occurs when magnetism disappears, but here, since the magnetism disappears when you make the circuit, you do not get any spark at make, because the circuit is already made. You do not get any at break, because at break there is no magnetism. The fifth and last of these electromagnets is wound according to a plan devised by Mr. Langdon-Davies, to which I alluded in the middle of this lecture, the bobbin being wound with a number of separate coils in parallel with one another, each layer being a separate wire, the separate ends of all the layers being finally joined up. In this case there are 15 separate circuits; the time-constants of them are different, because, owing to the fact that these coils are of different diameters, the coefficient of self-induction of the outer layers is rather less, and their resistance, because of the larger size, rather greater than those of the inner layers. The result is that instead of the extra currents running out all at the same time, it runs out at different times for these 15 coils. The total E.M.F. of self-induction never rises so high, and it is unable to jump a large air gap, or give the same bright spark as the ordinary electromagnet would give. We will now experiment with these coils. The differential winding gives absolutely no spark at all, and second in merit comes No. 5, with the multiple-wire winding. Third in merit comes the coil with intervening layers of foil. The fourth is that with copper sheath. Last of all, the electromagnet with ordinary winding.

CONCLUSION.

Now let me conclude by returning to my starting point—the invention of the electromagnet by William Sturgeon. Naturally you would be glad to see the counterfeit presentment of the features of so remarkable a man, of one so worthy to be remembered amongst distinguished electricians and great inventors. Your disappointment cannot be greater than mine when I tell you that all my efforts to procure a portrait of the deceased inventor have been unavailing. Only this I have been able to learn as the result of numerous enquiries; that an oil painting of him existed a few years ago in the possession of his only daughter, then resident in Manchester, whose address is now unfortunately unknown. But if his face must remain unknown to us, we shall none the less proudly concur in honouring the memory of one whose presence once honoured this hall wherein we are met, and whose work has won for him an imperishable name.

LEGAL INTELLIGENCE.

SAMUEL v. THE LONDON ELECTRIC SUPPLY COMPANY.

A Case of Trespass by Electric Light Men.

In the Queen's Bench Division of the High Court of Justice, on Monday last, this case came before Mr. Justice Grantham and a common jury.

Mr. Winch, Q.C., and Mr. Henry Kisch were counsel for the plaintiff; Mr. Lockwood, Q.C., and Mr. A. M. Bremner appeared for the defendants.

It was an action to recover damages for trespass to the plaintiff's stable, situate in Brad-street, close to the bridge of the South-Eastern Railway Company at Waterloo Bridge. The defendants, while disputing part of the plaintiff's claim as regards a horse paid £15 into court to satisfy any loss the plaintiff might have sustained in respect of any hay damaged. According to the plaintiff's case, the servants of the company trespassed on to his roof at the stable and adjoining loose box while cutting the cable which runs to Deptford to test it. He said that on December 5, 6, and 7, 1889, quantities of hay amounting to four loads, worth £12, were damaged by rain-water penetrating through the roof. As to the loose box next door, he said that a valuable cart horse, which he had purchased two years ago as a four-year-old for £40, and which was worth at least £60, as being capable of drawing 2½ tons, had through the wet and damp caught cold and contracted a kidney disease, of which it subsequently died. Before this happened the horse was sold and fetched £9. 1s. 6d., and this was deducted from the amount sued for. The case for the defence was that, as to the loss on the hay, it was very much exaggerated; that not more than a dozen or 15 trusses were injured, as one of the gentlemen connected with the company deposed to seeing, on December 17, the day after the plaintiff gave them notice that the hay and roof were damaged. They said that there had been nobody walking on the roof at all after October, but they admitted having replaced, after application, 156 slates on the stable (No. 1) after their attention had been called to the matter. As to the loose box (No. 2), they said that their workmen had never been on the roof at all, and that if the horse caught cold it must have been in the other stable.

Mr. Justice Grantham, in summing up, said the strange thing was that, if the mischief was done to the roof in October, no injury was apparent in the stable before December 5, 1889. But that perhaps might be accounted for if the season had been dry during the intervening time. The defendants contended that the price of the horse was exaggerated; but it did not seem unreasonable to ask £60 for a strong cart horse of such draught power, which cost £40 as a four-year-old two years ago. If the jury found a verdict for the plaintiff, they would say how much he was entitled to recover on the item of the hay, and how much as regards the horse, if its injuries were due to the negligence of the defendants' servants.

The jury retired to consider their verdict, and, after an absence of 45 minutes, returned into court with a verdict for the plaintiff for £65, inclusive of the £15 paid into court.

COMPANIES' MEETINGS.

NATIONAL TELEPHONE COMPANY.

A meeting of this Company was held on Thursday morning at the Cannon-street Hotel, Mr. F. R. Leyland, president of the Company, in the chair. The meeting was very largely attended, many shareholders being unable to obtain seats.

The **Chairman** said that this was not one of their usual meetings, it was more in the nature of a conference between Directors and shareholders for the purpose of explaining the present position of the Company now that the first of their master patents had expired. Referring to the accounts (which had not been audited) as made up to 31st October last, that was for the first six months of the Company's current year, he said the Company had earned a net profit of £108,170. 19s. 11d. This sum, together with £11,113. 9s. 7d. brought forward from last account, left an amount of £119,284. 9s. 6d. standing to the credit of profit and loss account. Out of that sum they had paid an interim dividend amounting to £62,973, and they had in hand £56,311, which, together with the profits that would be made in the second six months of the year, they would have to dispose of at their next annual general meeting. These figures were very satisfactory. The revenue account to April, 1890, showed a net profit of £185,754; the same profit on that account for the six months of this year was £104,765. If they divided £185,754 by one-half they would get £92,700, about, but instead of that they had for the six months £104,765. Last year they called up £260,000 for an issue of 52,000 new ordinary shares, and they (the Board) assured the shareholders that that new capital would give them just as good a profit as the old capital. That view had been realised. The revenue on April 30, 1890, showed a percentage on capital at that time of 8¾ per cent. Out of that they paid 6 per cent. dividend, and carried the other 2¾ per cent. to reserve fund principally, and a part forward. They then issued £260,000 new capital. What was the increased profit on revenue account for the six months? It was £11,891, and that gave them as nearly as possible 8¾ per cent., which was just the same thing, but they had the dividend on a larger capital, and that was a desirable thing, because the bigger the Company was the stronger and more impregnable they were against competition. Between October 31 and December 31, 1890, their rates remained the same, and there was the ordinary normal increase of the business, so that the ratio in the profits would be maintained, and, he thought, slightly exceeded. After that date, on 1st January, when the first master patent expired, they thought it wise, although the second master patent did not expire until July, 1891, to make a reduction in rates. The first result of that was, of course, that the revenue was reduced; but, on the other hand, they believed the reduction would bring in a great number of additional subscribers who would not otherwise have come on to their system, and in that way they would recoup the whole of that loss, and, he thought, more quickly than they would imagine. The net increase in the number of subscribers over the six months from April to October last, was 1,940. Dividing that by the number of weeks, it would give them an average per week of about 75. The increase in subscribers for the first three weeks of this month, January, had been 651. If that increase was kept up, and he saw no reason why it should not be, it would be a comparatively short time before the whole of the loss of revenue caused by the reduction in rates would be recouped, and they would have an infinitely stronger business. He did not think the possession of a monopoly such as they had enjoyed was an unmixed blessing. He would now deal with the capital expenditure of the Company. Every increase of business necessarily involved, in that Company, an increased expenditure on capital account. They could not link up a fresh town or put up an additional subscriber without this expenditure being increased. It was unavoidable so long as they pursued their present policy of extending business and covering the ground, which was their sheet anchor. They had expended in the first six months of this year (Company's year) on the construction of exchange, trunk and branch lines, the large sum of £96,970. A considerable portion of that, £40,000 or £45,000, went in linking up different towns in the provinces. The total number of towns linked was 244, and they were now in communication with each other. That was what he thought would prove to be the salvation of the Company, because any competitor could only give a local service unless he was prepared to spend the enormous amount of money they had spent in linking up the different towns in the kingdom. The greater portion of that £96,000 was now yielding a very satisfactory and growing revenue. They were gradually bringing every town that offered a fair chance of revenue into communication with the main centres in the provinces. If they had not pursued this policy of covering the ground, they would have had plenty of people glad to take the business. At the last meeting, speaking on this point, he said that increased capital must be obtained, and he told them that the Directors had not made up their minds as to whether the best mode of raising it would be by preference shares or by debentures. They had considered the matter thoroughly since, and had come to the conclusion that the best thing for the Company was to raise that money in debentures. He thought it was the cheapest way, and it avoided many of the complications arising from preference shares, of which there were two classes, and it would not do to have a third class. Having come to that conclusion, the Directors accordingly intended to issue perpetual debenture stock from time to time for the necessary purposes of the Company. They must make the issue a part of a very large sum, so that any subsequent debentures that they might issue would all rank alike. They must not have first, second, or third debentures. He would propose, and the Board had thoroughly considered the matter and also proposed, that they should create at once as large an amount of that debenture stock as their articles of association authorised. In their first issue they proposed only to raise enough money to pay off the existing debentures as they were entitled to. That was, a sum of £80,000. They would give gentlemen holding debentures the option—and many of them, he knew, would be only too glad to avail themselves of it—of taking their debentures, not in cash, but in exchange for other debentures of the Company. It would be better for them to be the holders of debentures in a large stock (which would be certainly quoted on the Stock Exchange, and greatly dealt in) than to be holders, as they now were, of a small issue of £75,000, for which there was neither sale nor power of purchase. Now they had to repay to capital account that £97,000 that they had spent up to the 31st October last, out of revenue, and he thought they ought to hold in hand a sufficient amount to carry them on to the end of their year, so that they should not be continually coming to them suggesting fresh capital. Fresh capital would have to be raised if their business went on, unless they made up their minds to relinquish it. They (the Board) thought the first issue ought to be something between £300,000 and £350,000.

He had now given them pretty nearly all the facts of their position, and the Board's view of that position was that it was a very favourable one, and that it gave, and ought to give, every shareholder great confidence in the future of that Company. At the same time the Board would be glad to listen to suggestions, and invited remarks from shareholders, so that any doubts might be removed and explanations made. There was no resolution to be proposed, and he would now sit down and hear what shareholders had to say.

Mr. Chipperfield asked that the list of towns linked together might be furnished to shareholders, and as to the present debentures.

The **Chairman** said the list should be circulated. The present debentures were perpetual stock, and amounted to £73,000; but the Company had the right of repaying these debentures at any time on payment of 10 per cent. premium; that was why he said it would take about £85,000 to clear them off. They paid 4½ per cent. interest on the present debentures. He could not say what they would pay on the new issue except that they would get them at as cheap a rate as possible.

Mr. Watson asked what injury was likely to occur to the Company from the expiry of the companies' patents.

The **Chairman** said the first result would be that all the world could use them. Up to the present they had had a practical monopoly. When the two patents were up everybody could interfere with them. But their policy had been to cover the ground—to be the man in possession. The bigger their business was, the less in proportion were the working expenses. What the result would be neither he nor anyone else could foresee. He had shown them that there were strong indications that the loss they suffered in the first instance by the reduction of rates, would be recouped by the accession of additional business. He could not prophesy more.

Mr. Watson asked if there was anything to oppose the Company now.

The **Chairman** said nothing except the company in Manchester, and they had had difficulty enough to get their money, and that was only £43,000.

Mr. Salter wanted to know if the through speaking lines to Manchester, etc., were likely turn out satisfactorily from a monetary point of view.

The **Chairman** said that in the main towns—Manchester, Liverpool, Glasgow and Bradford—and all towns of that kind, the reduction in rates had been from £15 to £10. In London they had made no reduction. In the provinces people paid for a radius of one mile from the exchange; some of them were not so far away. The radius in London was very much greater, and, in addition, the expenses were enormous. The wages there were double what they were in other places. That was a sufficient reason for the difference in rates between London and the provinces. Independently of that, he thought the main point in regard to London was not so much reduction of rates as increased efficiency. They had done a great deal in this way, but a good deal had yet to be done. Efficiency was the main thing in London, not reduction of rates. The amount of revenue they had derived from through lines up to the present was very small, but he was disposed to think that they would have to consider other ways of making these lines profitable. They had had enquiries from people having business connections in Liverpool and Manchester who wished to have a line to themselves, or the use of a line at certain hours. Others wanted to combine—two or three firms together—to have a line. Then, again, at night-time the papers wanted the lines. He was convinced that the working of these lines would grow. These remarks did not apply to the lines linking provincial towns together, from which they had a very large revenue.

Dr. Ellis asked if the existing poles carrying wires to Birmingham and Manchester were capable of carrying additional wires.

The **Chairman**: Certainly.

In answer to other questions the **Chairman** said their reserve fund was invested in their own business. He was not under the impression that a reduction of rates in London would bring a large accession of business, as Mr. Falke thought. The working expenses for the six months up to October came to exactly the same as last year—viz., 40 per cent. on the gross revenue. Last year the total crude income was £364,704. In the half-year ending April 30th, the income was £205,578. They had agreements with subscribers for periods of three, five, or seven years, as Mr. Biden suggested. They were on good terms with the Post Office. They were considering the question of obtaining a Bill giving them statutory powers to run their wires.

A hearty vote of thanks to the Chairman and Board was carried by acclamation on the motion of **Mr. Chipperfield.**

DIRECT UNITED STATES CABLE COMPANY.

The twenty-seventh ordinary general meeting of this Company was held on Friday, 16th inst., at Winchester House, Old Broad-street, Sir J. Pender, K.C.M.G., in the chair.

The **Chairman** said that the past year had been rather an eventful one, in some respects, commercially, both here and in America; at the same time he thought England had come out of it in a marvellously satisfactory manner. He hoped that the new departure which was being made in commerce would be largely beneficial to the telegraphic system. He would like to go back to the 5 per cent. dividends, but the only way to obtain them was by doing their work better, and by encouraging the development of the telegraphy between the old and the new world. The money that the Company was at present earning from the Atlantic traffic was about the same in amount as when the tariff was higher. Other companies now competed with them, and shared that traffic. The Company was doing its work wonderfully well, and was earning a fair amount of the traffic. There was a familiar saying that "a new broom sweeps clean." The Directors had to contend against these "new brooms," but he declared that experience could often bring about better results. The revenue for the past half-year, after deducting outpayments, was £43,347, and the working and other expenses amounted to £17,556, leaving a balance of £25,791. An interim dividend at the rate of 3s. 6d. per share for the quarter ending September 30 has been paid, and the Board recommended a similar distribution for the past three months, leaving £5,511 to be carried forward. The revenue for the half-year showed an increase of £990, equal to 2¼ per cent. over that of the corresponding period of 1889. He believed that telegraphy would never sleep, but would go on progressing. At the stations the expenditure had been £1,586 more, chiefly owing to their having now to bear the whole of the expenses of the New York office (instead of one-third only, as in 1889), and, secondly, to the prosecution of an active canvass for business on the Continent of Europe, as well as in the United Kingdom and New York and Boston. Their reserve fund, after being debited with £1,629 for the cost of repairs, and credited with £4,307 for interest on their investments, now stood at £252,678. The investments continued to be worth much more than their cost price, at which they appeared in the balance-sheet. The shareholders had receive the same dividend as had been paid to them for the last two or three years, and he would be very much disappointed if this rate were reduced. He moved the adoption of the report.

Mr. William Ford seconded the motion.

A brief discussion followed; and, in reply to Mr. Jackson, the **Chairman** reminded the shareholders that the litigation with the Compagnie Française du Télégraphe de Paris in New York was being conducted entirely by the Anglo-American company. The fact that this matter was not yet settled was not, however, the cause of their paying a dividend of 3½ per cent. instead of 5 per cent. The fact was that if they were paid according to the first prospectus which the Anglo-American company issued, the shareholders would now, he supposed, be receiving 200 or 300 per cent. They had, however, now to contend against science, codes, and competition between the different companies.

The motion was carried unanimously.

COMPANIES' REPORTS.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The Directors of this Company recommend a balance dividend of 15s. per cent. upon the ordinary consolidated stock, and of £1. 10s. per cent. upon the preferred stock for the year ending December 31, 1890, both payable on January 31 next, less income tax, to the stockholders registered on the books of the Company on the 13th inst., leaving a balance of £44 to be carried forward. The above dividends, together with those already paid, will amount to £2. 17s. 6d. per cent. on the ordinary, and £5. 15s. per cent. on the preferred stock for the year 1890.

CITY NOTES.

Brazilian Telegraph Company.—The receipts for last week amounted to £6,099.

City and South London Railway.—The receipts for last week were £758, an increase of £10 over the preceding week.

The Commercial Cable Company announce that they have established offices at 8, Foster-square, Bradford, and 37, Albert-square, Dundee.

Notice of Removal.—The Fowler-Waring Cables Company, Limited, have transferred their London office to 4, Victoria-mansions, 32, Victoria-street, Westminster, S.W.

West India and Panama Telegraph Company.—The receipts for the half-month ended January 15 were £2,596 against £3,001; the September receipts, estimated at £4,789, realised £4,884.

Eastern and South African Telegraph Company.—This Company announce the payment by warrants on Feb. 2 of interest for the half-year ending Jan. 31 on their 4 per cent. mortgage debentures.

Western and Brazilian Telegraph Company.—The receipts for last week, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,935.

Eastern Telegraph Company.—This Company notify that the coupons on their 5 per cent. debentures, due Feb. 2, will be paid by Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

NEW COMPANIES REGISTERED.

North-Eastern Telephone Company, Limited.—Registered by Waterlow Brothers and Layton, 24 and 25, Birchin-lane, E.C., with a capital of £4,600 in £1 shares. Object: to carry on the business of a telephone, telegraph, and electric light, heat and power supply company. There shall not be less than three nor more than five Directors. Qualification, £100. Remuneration to be determined in general meeting.

PROVISIONAL PATENTS, 1891.

JANUARY 12.

573. **Improvements in devices for hanging pictures, especially applicable to the casing of electrical conductors.** William James Rundle, Frank Benjamin Lea, and Anthony George New, 11, Furnival-street, London.

580. **Improvements in and relating to phonographs.** Frank Mitchell, 70, Chancery-lane, London.

584. **An improved construction of alternate-current dynamo electric motors.** Maurice Hautin and Maurice Leblanc, 28, Southampton-buildings, London.

587. **Improvements in or connected with incandescent electric lamps.** Frederic Harman Peter Berlyn, 23, Southampton-buildings, London.

593. **Improvements in electric primary batteries.** Theophilus Coad, 1, Quality-court, London.

JANUARY 13.

608. **Improvements in construction of channels for the use of electric conductors in streets.** Thomas Parker, Wolverhampton.

616. **An improved carbon stick or pencil for arc lamps.** Herbert John Allison, 52, Chancery-lane, London. (Barton Brewer Ward, United States.) (Complete specification.)

617. **Improvements in the construction of electric arc lamps, and appliances used therefor.** Herbert John Allison, 52, Chancery-lane, London. (Barton Brewer Ward, United States.) (Complete specification.)

624. **Improvements in electrical elevator apparatus.** American Elevator Company, 55, Chancery-lane, London. (Otis Brothers and Co., United States.) (Complete specification.)

641. **Improvements in electric clocks.** Emil Gustavus Hammer, 55, Chancery-lane, London. (Complete specification.)

647. **Improvements in electrical measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Weston, United States.) (Complete specification.)

649. **Improvements in and relating to electric elevators or lifts.** Henry Harris Lake, 45, Southampton-buildings, London. (Rudolf Eickemeyer, United States.) (Complete specification.)

650. **Improvements in electrical apparatus for indicating the progress and result of races, games, and the like.** Henry Harris Lake, 45, Southampton-buildings, London. (Samuel Dimmick Mott, United States.) (Complete specification.)

657. **Improvements in conduits for electric conductors.** Henry Harris Lake, 45, Southampton-buildings, London. (Arthur Lord, United States.) (Complete specification.)

667. **Improvements in electrodes for voltaic accumulators.** William Phillips Thompson, 6, Lord-street, Liverpool. The Hess Electric Storage Battery Company, United States.) (Complete specification.)

668. **Improvements in or appertaining to voltaic accumulators.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Hess Electric Storage Battery Company, United States.) (Complete specification.)

669. **Improvements in electrical cut-outs or safety fuses.** Johann Puluj, 323, High Holborn, London. (Complete specification.)

675. **A new or improved electric regulator.** Royal Edward Ball, Norfolk House, Norfolk-street, London. (Complete specification.)

JANUARY 15.

743. **Improvements in the application of electricity for mining purposes.** Walter Osmond Rooper, 23, Greengate-street, Stafford.

JANUARY 16.

846. **Improvements in electrical cables.** Walter Victor Morten, 2, Lithos-road, South Hampstead, London.

JANUARY 17.

860. **An electric bell repeater. An electric bell and receiver for electric signals.** Arthur Henry Bagnold, Borstal Cottage, Rochester.

861. **Improvements in the insulation of metals for electrical purposes.** George Lee Anders and Charles Herbert Elliot, 10, Bush-lane, London.

871. **Improvements in telephone transmitters.** James Frederick Bennett and Ernest Parker Hides, Howard Villas, Rupert-road, Nether Edge, Sheffield.

884. **Improved apparatus for the production of electricity.** Charles Wells, 22, Southampton-buildings, London.

889. **Apparatus for manufacturing corrugated lead boxes for electric accumulators.** Woodhouse and Rawson United, Limited, 28, Southampton-buildings, London. (Thomas Knight Steanes, Australia.)

899. **Improvement in electric cells or batteries.** Henry Thomas Eager and Richard Philip Milburn, 433, Strand, London.

908. **Improvements in insulators for electric wires.** Frank Atherton Ross, 53, Chancery-lane, London. (Complete specification.)

910. **Electromagnetic mechanism for controlling the transmission of power.** Alexander Melville Clark, 53, Chancery-lane, London. (Washington H. Kilbourn, United States.)

SPECIFICATIONS PUBLISHED.

1884.

10990. **Telephony.** Langdon-Davies. 8d. (Second edition.)

1886.

16616. **Telegraphy.** Langdon-Davies. 11d. (Second edition.)

1889.

20974. **Electric supply.** Van Rysselberghe. 8d.

1890.

135. **Alternate-current motors.** Atkinson. 8d.

1246. **Electrolytic generation of chlorine, etc.** FitzGerald and Falconer. 4d.

3133. **Incandescent-arc electric lamps.** Boardman. 8d.

4000. **Electric regulators.** Pieper. 8d.

4028. **Electric telephone transmitters.** FitzGerald. 6d.

7044. **Electric conductors.** Lake (Brooks.) 6d.

9797. **Electric circuit controlling apparatus.** Alexander. 8d.

10122. **Electric railways.** Dewey. 8d.

12997. **Electrical rock drill, etc.** Brain and others. 6d.

19057. **Electric arc lamps.** Thompson (Beach.) 6d.

19097. **Incandescent electric lamps.** Clark (Bornholdt and Glatz.) 6d.

19162. **Electric welding and metal working.** Dewey. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	1½
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	7¼

NOTES.

Dorking.—The authorities are expected to take practical steps for the immediate introduction of the electric light.

Cambridge.—Dr. Fleming is busy deciding upon the details of the scheme of electric lighting for Cambridge. The system so successfully employed at the Berlin central stations is in favour.

Chili Cables.—Owing to the revolt in Chili, telegraphic communication by the Mexican West Coast cable is interrupted south of La Serena. The Valparaiso cable stopped operations on Jan. 22.

Stephen Gray.—In the *New York Herald* appears an interesting article on the veteran electrician, Stephen Gray, who even before Franklin determined that electricity and *lightning* are identical.

The Edinburgh Exhibition.—It has been arranged that a first dividend of 12s. 6d. in the pound shall be paid by the liquidator to the creditors of the recent Edinburgh International Exhibition.

Death.—A Reuter telegram from Rio de Janeiro announces the death of M. Benjamin Constant, Minister of Public Instruction, Posts and Telegraphs, and ex-Minister of War in Brazil.

Mr. Drake's Accident.—Mr. Drake has sufficiently recovered from his severe accident to enable him to be conveyed home from the Westminster Hospital, and it is hoped that he will in time thoroughly recover from the effects of his fall.

Odessa Telegraphs.—Long sections of the telegraph lines in South Russia ending at Odessa have broken by the unusual prevalence of dense fogs which have frozen on the lines and weighed them down. Several cases of freezing to death of the linesmen are reported.

Lane Fox Patents.—An agreement has been entered into between the Lane Fox Electrical Co., Ltd., and the St. James and Pall Mall Electric Light Company, whereby the St. James Co. take a license to work under the Lane Fox distribution patents and pay a royalty to the Lane Fox Co.

Electrical Pocket-Book.—Prof. S. P. Thompson is bringing out an electrical engineers' pocket-book—a tiny little *vade mecum* actually capable of going into a waistcoat pocket, and filled with just that sort of practical information, figures, and references that are wanted on the spur of the moment in actual work.

Maxim-Weston Plant.—Messrs. W. R. Pryke and Co., hardware merchants, of 48, Upper Thames-street, E.C., have completed arrangements for the purchase of the valuable plant, machinery, and stock, formerly the property of the Maxim-Weston Electric Co., Ltd., at their extensive works, Kingsland-green, London, N.E.

Exhibition at St. Pancras.—The clerk of the Vestry of St. Pancras has presented a report to the Electric Light Committee with reference to the subject of holding an exhibition of electrical appliances at the Vestry Hall for the ratepayers' information. The committee has approved of this idea and the exhibition is to be held shortly.

The Electric Motor Business.—The Edison Company of Boston, U.S., is at present furnishing current for 504 electric motors having a total capacity of 1,450 h.p. These are run on a 220-volt circuit. During the past month contracts for 72 h.p. have been closed, and the average for the past 18 months has been 50 h.p.

Christmas Tree at the Foundling Hospital.—Mr. Pitkin, of Red Lion-street, is lighting up the annual Christmas tree at the Foundling Hospital yesterday and this evening. There are 100 8-volt lamps, run a set of portable accumulators. These are slightly over-incandesced, and the effect is thus obtained of a number of stars, a very surprising and pleasing effect for the amusement and pleasure of the children.

Insulated Wire Works.—We have received samples of lead-covered cables for electric light, and also for telephone purposes, from the British Insulated Wire Company, made under the patents of the Norwich Insulated Wire Company, of New York. Works are being constructed on 10 acres of land communicating with the London and North-Western Railway at Prescot Station, Lancashire. These works are to be finished by the end of the year.

King's College.—An appeal is being made for the sum of £50,000 to enable the council of this college to meet the increasing demands of education, particularly in regard to modern science and experimental research. The council have received several liberal gifts and promises, amongst them one from Lady Siemens of £6,000 for the establishment of an electrical laboratory. Donations to the King's College extension fund may be made to Messrs. Coutts and Co., or to the secretary.

New Cable.—A Reuter's telegram, dated Washington, Jan. 28, says: Mr. Mitchell introduced a Bill in the Senate yesterday sanctioning the incorporation of a Pacific Railway Cable Company, with a capital of 5,000,000dols., which would work a cable between San Francisco, Hawaii, Samoa, and Japan. The Bill provides that the majority of the directors shall be citizens of the United States, and authorises the Treasury to pay the company an annual subsidy of 200,000dols. for 15 years.

Transmission of Power in Spain.—An installation for transmission of force, the first on a practical scale in Spain, was inaugurated a few days ago at San Juân las Fonts, in the province of Gerona. A paper mill receives 50 h.p. transmitted a distance of nearly a mile. The dynamos are driven by turbines, and the current is conducted along bare copper wires of 8 mm. diameter, suspended on porcelain insulators mounted on ordinary telegraph posts. All the material are made by Messrs. Planas, Flaguer, et Cie., of Gerona.

French and German Government Cables.—The following rather important item of news is given in the *Electrical World*: "The Standard Underground Cable Company, of Pittsburgh, has secured a contract from the French Government for the erection of a plant with which to manufacture the underground cables for that republic. A. J. Waring will sail for Paris to begin at once the work. The French Government has determined to bury all the wires under its control. The plant which the Pittsburgh concern is to build will turn out about a million and a half dollars worth of cable wire yearly. The same corporation is negotiating for the erection of similar works in Berlin."

O.S.A. Conversazione.—On Saturday, January 24, a most enjoyable evening was spent at Prof. Perry's house, 31, Brunswick-square, Mrs. Perry having kindly invited the members of the Old Students' Association of the City and Guilds of London Institute to an "At Home." A very excellent programme of music was provided—violins, Mr. Gatehouse and Miss Doughty; 'cello, Mr. Roger Bucknall; vocalists, Miss Cherry and Mr. Howden Tingey; accompanyists, Mr. C. G. Lamb and Miss Doughty. In all there were about 200 persons present, most of whom were students and their friends, but in addition to these there were several distinguished electrical and scientific men, amongst whom we may mention Profs. Ayrton and Meldola, and W. H. Preece, Esq.

A Permanent Electrical Museum.—Two years ago in Prof. Flowers's presidential address before the British Association, great stress was laid upon the advantages and upon the need of organisation of museums. We took the opportunity, in our issue of September 13, 1889, to advocate the necessity for the establishment of a permanent museum for the electrical profession in conjunction with the present Institution of Electrical Engineers. We are given to understand that now the Institution has had to remove its quarters from its old *habitat* to Victoria-mansions, the possibility of some action in this direction is contemplated, and that the matter will be brought before the Institute, and we are pleased to see our contemporary, *Electric Plant*, in a forward proof kindly sent to us for remark, is actively advocating the same proposal.

Bath.—We are glad to learn that considerable and gratifying improvements have taken place at the Bath central station. The festoons of wire and other temporary arrangements that made this station look somewhat like a Yankee station have given place to the neatness and solidity that should distinguish English engineering work. The high-potential terminals also—previously a source of our complaints—are now covered in with glass and out of harm's way, and matters have smoothed over considerably since the new chief engineer took up his work there. The supply of current has been remarkably steady and regular. The Bath authorities charge a fine of some shillings for every extinction of lamps, yet in last quarter's account only 8s. was deducted on this account, while during this period some 60 of the gas lamps yet in use were out.

Electric Light in Irish Railway Carriages.—The Great Northern Railway Company of Ireland have lighted up one of the trains by electric light, and the results of the trial of the morning mail from Dublin to Drogheda are very satisfactory and justify extension. The arrangements were carried out by the Electrical Engineering Company, of 61, Dawson-street, Dublin. There are 18 accumulators, and four 5-c.p. lamps in the first-class carriages, with very handsome fittings. All lamps except one can be turned off at will. There are two lamps in the second classes. The cells supply current for 10 hours at 35 volts. A Brush engine and Stockport gas engine are being erected to charge the cells for further experiments with the mail trains, and arrangements will be made for charging by means of the dynamo on the train if the scheme is carried through.

Brighton.—The work upon the central station at Brighton is being pushed forward rapidly. Already the roof is on the building. The Goolden dynamos were tested last week at Messrs. Willans and Robinson's, and gave extremely good results. The conditions stipulated a rise in temperature of not more than 60deg. F. after a run of 12 hours. The tests showed an efficiency from engine to dynamo of 85 to 86 per cent. on a 75-h.p. engine. The temperature was only 20 per cent. on the fields and 60deg. on the armature after seven hours' run, and steady at this temperature. The laying of the mains at Brighton is in the hands of the Callender Company, and work is actively commenced. Special means of connecting and disconnecting the feeders and branch mains anywhere in the network are here adopted, as will be described in our articles on these mains, commencing this week.

Vaughan-Sherrin at the Cycle Show.—Mr. Vaughan-Sherrin has got his foot into the cycling world, and may be expected to astonish both users and manufacturers. One of his electric Bath chairs are on view at the Stanley Cycle Show at the Crystal Palace, and is creating a good deal of interest. It may be remembered we described a test journey with an old Bath chair, fitted up with one of Mr. Vaughan-Sherrin's motors and batteries, which went well and easily. A well got up specimen of this electric Bath chair is shown amongst the other novelties of the cycling season. The smallness and lightness of the battery required to supply power is the principal feature, the weight of the two troughs of cells required to drive the chair and its occupant five miles an hour for eight or nine hours being only 100lb. The application to an actual tricycle is also shown.

Glasgow Telephones.—Complaint is being made at Glasgow that whereas subscribers engage to pay £10 a year for five years to the National Telephone Company, and have to continue payment even if disconnected before that time, yet the company are exempt from responsibility if the service is not kept up. At a meeting at the Corn Exchange it was explained that a great number of members of the trade had subscribed to the Mutual Telephone Company, whose system is expected to be completed and in working order in the course of two or three months, and which is represented to give a more efficient service at £5 per annum within the one mile radius, or half the reduced rate of the National Telephone Company. Those whose contracts were expiring with the old company were warned not to commit themselves for more than one year. It was resolved that the meeting support the new company.

The London and Paris Telephone. — As telephonic communication is to be opened between London and Paris early in March, M. Jules Roche, Minister of Commerce, it is stated, is at present engaged in drawing up the conditions for the working of the service. The Minister is also occupied with the draft of a convention with the British authorities, of which the following would be the essential points. The charge for the use of the telephone would be 10 francs for a three minutes' conversation. This charge would at first be only experimental, and might be reduced should experience render such a step advisable. The telephone might be used at any time, day or night. The correspondents of the two nations would be granted alternately the privilege of availing themselves of the new means of communication. The British authorities, on their part, will adopt such measures as they may deem fit.

Electrical Examinations.—The manager of the School of Electrical Engineering, Mr. L. Drugman, informs us that as the result of recent examinations the following students have now obtained the vellum certificate of the school. (*a*) In electric lighting and power transmission: Messrs. A. C. D. Crommelin, B.A., J. Finlay, J. F. Irgens, H. Macfarlane, L. Marchetti, F. J. Moffett, B.A., R. J. F. Mostyn, J. W. Parr, P. F. W. Simon, P. J. S. Tiddeman, H. Treherne, L. W. Wild, C. B. Wigg. All these students belonged to the advanced class (instructor, Mr. Charles Capito, M.I.M.E., M.I.E.E.). This examination was conducted by Mr. Gisbert Kapp, M.I.C.E., M.I.E.E., and consisted of a paper in mechanical engineering, a paper in electrical engineering, a *viva voce* and practical examination, and drawing. (*b*) In telegraphy and telephony, Mr. H. Treherne, above named. This examination was conducted by Mr. H. R. Kempe, A.M.I.C.E., M.I.E.E., of the Engineer-in-Chief's office, General Post Office.

The City Commission of Sewers.—At a meeting of the City Commission of Sewers held on Tuesday at Guildhall, the Commission resolved that a petition be presented to provide, in regard to the London Overhead Wires Bill, against any alterations being made therein prejudicial to the jurisdiction of the local authority. On the question of presenting petitions against the Central London Railway and the City and South London Railway (Islington Extension) Bills, to enable the Commission to offer such opposition as might be deemed expedient, Mr. A. A. Wood said the two underground lines would cross beneath the roadway in front of the Mansion House, and there was this radical defect, that the tubes of the two companies were of different sizes, so that if the exigencies of the traffic should eventually require it, there would be no possibility of linking the two lines together. The Court resolved to petition against the Bills, with a view to obtain *locus standi* to insert amendments should the necessities of the case thereafter require it.

Showroom Fittings.—Some little difficulty and trouble is generally experienced in arranging the connection of electroliers and pendants in showrooms. Often a large number are shown, and are desired to be so arranged as to give the possibility of lighting any pendant to show to visitors. This necessitates, when fittings are taken down or changed, much screwing and fitting of connections. Now, the best and simplest way for fittings in showrooms is evidently that employed for transportable fittings generally—namely, with wall sockets. Accordingly, in one of the best-known electrical showrooms the system is employed of running many circuits on the ceiling, each circuit fitted with several wall sockets, and alongside each wall socket an ordinary brass hook. This hook takes the weight of the electrolier, and any electrolier or pendant can be hung up, taken down, altered in position, and nevertheless be lighted at once by this use of abundant wall sockets on the ceiling instead of ceiling roses. The saving of trouble and gain in ease make this simple system worthy of being employed in electrical fitting showrooms.

The Reform of Science Teaching.—The reform in the methods of science teaching in schools and colleges, in aid of which we have attempted to throw what influence we have in the department of electrical engineering science, seems to be also a matter of considerable discussion at this instant in France, between two members of the Academie des Sciences (and also of the Academie Française), M. de Freycinet, Minister of War, and M. Joseph Bertrand, classical mathematician. The point of discussion is the reform in the system of examinations, especially of the matriculation of the Ecole Polytechnique. The examinations, it is maintained, are a quarter of a century behind the times, surcharged with a mass of antiquated accessories, tending to stifle the minds of the students to real learning and develop simply a false vivacity in cramming useless and merely gymnastic exercises—memory being substituted for reflection and true grasp of the subjects taught. We wish the reformers every success in their crusade, which is doubtless as much needed the other as it certainly is this side of the Channel.

Proposed Extension of the Electric Subway.—A movement is on foot among some influential residents of Peckham and East Dulwich with the object of obtaining an extension to those districts of the electric railway recently opened between King William-street, City, and Stockwell. A largely-signed memorial of the inhabitants has been drawn up, praying the local authorities to increase the railway accommodation of the district, which, it is complained, is at present far from satisfactory; and the Camberwell Vestry officials will shortly approach the directors of the new electric company with regard to the matter. Should the company entertain the proposed scheme, it is suggested that their system should be extended from the Elephant and Castle, through the Walworth-road, on to Camberwell-green, and thence down the Peckham-road to East Dulwich and Nunhead. At present the trains of the London and Brighton Company from East Dulwich to the City go only to the south side of London Bridge, an arrangement by which much inconvenience is said to be caused in bad weather to travellers to the metropolis.

Visiting Deputation from Manchester.—The Manchester City Council are still undetermined whether to undertake the electric lighting itself or to advertise for tenders. In order better to arrive at a decision, a sub-committee has been appointed to visit a number of towns where central electric light stations are to be seen. This practice of recommending visits of deputations to towns already lighted is becoming quite common amongst corporations, and commends itself from the point of view of the dsirability of committee men obtaining practical knowledge at first hand. It is to be wished, however, that the committee before actually setting out upon their visit will take such steps as will enable their report to be a really useful, important, and enlightening one. The advice or co-operation of a competent technical engineer, combined with the business capacities of the committee, ought to bring forth much most useful information upon the status and prospects of various systems as applied to various towns, which would then more than justify the Corporation in their expenditure of time, money, and energy in visits to the electrically-lighted towns of England.

University College.—An appeal is being made for a sum of £50,000 for University College. The further funds are needed to provide for the teaching of new subjects, for the extension of buildings, for new teaching appliances which are rendered necessary by the advance of knowledge and improvement of educational methods, and for the better payment of teachers. The chief purposes for which money is now required are: 1. A new laboratory for the teaching of experimental physics. 2. Increased accommodation, apparatus, and machinery for teaching electrical engineering. 3. Increased accommodation and appliances for teaching mechanical engineering. 4. A collection of architectural models and accommodation for a school of architectural drawing. 5. Additional laboratory accommodation and apparatus for the work of supplementing the lectures of the Society for the Extension of University Teaching. 6. Further endowment of teaching, especially in the department of modern and Oriental languages. A committee has been formed, with power to add to its number, to appeal for funds for the above purposes, and the names of members of the committee, with a first list of subscriptions, will shortly be published.

Electric Fire Alarms.—A most suggestive piece of information is given in the annual report of the Glasgow Fire Brigade, which states that the damage done by fires attended by the brigade during the year just closed amounted to £43,500, as compared with £150,000 in 1889 and £206,000. Whence this sudden diminution, it may well be asked. The firemaster states: "Although several important buildings have been jeopardised during the year through the occurrence of fire in them, he is pleased to state that serious loss has in no instance resulted, this being in a large measure due to the early discovery of the outbreaks, and the speedy means of communicating with the brigade offered by the electric street fire alarms, which were used to intimate 200 fires last year," out of a total of 425 attended by the brigade. A result so striking is well worthy of being used as a lever to corporations by electrical firms capable of carrying out contracts for electric street fire alarms. The Edinburgh authorities are already being urged to adopt the system so successfully introduced by the sister town.

The objection of "malicious calls" is the one most urged, in answer to which it may be stated that out of a total of 500 calls in Glasgow, 29 only were "malicious," while the probable saving to the town was some £200,000.

Church's Slide Valve.—Two great industries are struggling for the method of making the production of power by steam engines more and more economical. These are the marine and the electrical industries. No other industries require constantly and usually such aggregations of engines of immense power. At present, except in one case not yet started, the marine engines are the larger, and have led the way in progress of economy of production. We are able to announce the very practical result just achieved by the adoption of a new type of slide valve, known as the Church's slide valve. Usually the slide valves of an engine act as a veritable break upon the engine, being pressed against the metal slides with the force of very nearly the whole steam pressure, 100lb., 120lb., or 160lb. per square inch. In Mr. Church's valve this pressure, by an ingenious application of simple principles, is almost entirely taken off. The result is best stated by the fact that one of the steamship companies have had these valves applied to one of their steamers, and while doing the voyage in less time, 390 tons of coal less were consumed on the voyage, representing a saving of some thousands of pounds a year, due entirely to the introduction of this valve. The principle upon which the new slide works is briefly this: that as at present used the steam presses the valve to the slide with full force of steam pressure; by making the slide in two parts, fitted together telescopically and admitting steam to the inner part of the slide valve, the steam is ingeniously made to press equally on all sides, and all strain is consequently taken off the slide valve itself, so much so that it is necessary to put in a spring to press the valve against the portholes. We understand that so satisfied are the company with the result that other ships are being fitted, and that Blairs, the well-known shipbuilders, have taken out a license, and will fit the Church slide valves to all ships now built. The invention should be equally useful for large electric central station engines.

Automatic Insulation Tester.—A new instrument has been invented, for which we prophesy immediate and extended usefulness as soon as it is put on the market. Before describing it let us just recall the conditions on an ordinary large private or other installation. The wiring is done by the best firm, we will suppose, by good men under good superintendents, with the best wire on the best Phœnix principles. The insulation is tested, and the tests show the best results—insulation so many megohms. The installation is passed, lamps are lighted, and all goes well—for a time. This time may be long or may be short, but accidents will happen, and deteriorations will occur, and sooner or latter a leakage may—we do not say must, but may—occur. There is usually no test, no warning of this. You do your best and then—trust to Providence. Now, in a central station, and more so still in an important installation, where technical men are not always about, it should be possible to have an immediate warning at the slightest giving way of the insulation. That is, at the first occurrence of a partial short circuit an indication should be given. Mr. Reginald J. Jones has invented a very simple little piece of automatic apparatus for this purpose, an adaptation of an easy test. Taking two lamps run in series (50-volt lamps for a 100-volt circuit) across the mains, the current through them, and therefore the brightness, will be the same in each. Connect the wire between the lamps to earth, and on the slightest leakage on either positive or negative wire one of the lamps will receive more current, and will therefore glow brighter. This will indicate to the eye of the attendant the commencement of danger. A polarised relay, starting an electric bell, will indicate the incipient danger to his ear. An American clock, moving contact hands, causes the instrument to be connected twice or several times in the hour, so that the state of the installation mains are constantly kept under test. Where thousands of pounds are in hazard the addition in large installations of this ingenious little time tester will be a welcome safeguard indeed.

Development of Bradford Central Station.—Extensions of considerable magnitude have been made at the Corporation electric works at Bradford, chief among which are a large set of Crompton-Howell accumulators. This addition was inaugurated last Tuesday by Alderman Priestman. When he arrived at the works one of the engines had been started, and was supplying the town. Alderman Priestman turned on the main battery switch, and gave instructions for the engine to be stopped. This was done, and the batteries solely supplied the current needful for the lamps then on, which, according to the indicators, were equivalent to 250 of 16 c.p. each. The whole battery contains 65 cells, of which 58 were then necessary to send the requisite pressure to the terminals of the lamps in the town. Later in the day as the output increased, more cells were switched on, thus maintaining a constant potential at the feeding centres. The accumulators will be able to supply 2,000 lamps of 16 c.p. each for an hour. The cells are each 5ft. 6in. long, 12in. broad, and 12in. deep. Each cell contains 67 lead plates 8½in. square and ⅜in. thick. The batteries will not be fully developed for some little time, as it is necessary to allow the plates to form. The charging is only by a Willans engine of 150 h.p., the charging current being 170 amperes. The trial of the accumulators was thoroughly successful. In transferring the lighting from the engine to the batteries no fluctuation whatever was discernible. There has been added to the plant at the works a Willans engine of 300 i.h.p., and working at a pressure of 140lb. to the square inch. This engine drives a dynamo capable of supplying 250 lamps of 16 c.p., by Messrs. Siemens Bros. It is the largest of its class turned out by this firm, and is one of the finest machines they have made. The total horse-power represented now at the station is about 800, there being, in addition to the engine in question, three of about 150 i.h.p. each. Since the beginning of November three new feeding mains have been put down in the town, but perhaps the best way of indicating the growth of the installation will be to say that when the works were opened in September, 1889, there were connected with them lamps of a total power equal to 800 candles only, whilst there are now lamps supplied representing 120,000 c.p.

Frankfort Exhibition.—The utmost efforts are being made by the executive committee of the Frankfort Exhibition to cause the eyes of all Europe, and especially all scientific Europe, to turn towards them as they did two years ago to Paris. The greatest possible employment will be made of the newest advances of electrical science. In the railway section there will be four model systems of electric railways. The three distinct systems will be represented—overhead conductors, underground conductors, and accumulator traction. The telephone section will include the original instruments designed by Reiss, the unfortunate professor who first realised this world-famous invention. The telephonic section will be put into communication with the concert-halls of Frankfort, Wiesbaden, and Munich. There will be printing and typewriting machines in communication with the central station, and automatic telephones will also be shown. A large section is devoted to electro-chemistry. Amongst electrical laboratory apparatus will be the "resonators" of Prof. Hertz. In the machinery hall there will appear 20 systems of dynamos and 40 kinds of engines, the total force being 3,900 h.p. Amongst the practical experiments in electrical transmission of power, which are to form such a noticeable feature of this exhibition, will be the transmission of 100 h.p. from the Frankfort Jardin des Plantes, where the generating station will be seen, and 100 h.p. from Offenbach, and, most striking of all—a standing demonstration to the world—the transmission of 300 h.p. from Lauffen-sur-Necker, a distance of 300 miles. This last will only be carried out if the Telegraph Department gives the consent which has been officially asked. There will be six batteries of accumulators, capable of supplying a current of 400 e.h.p. for several hours. Messrs. Siemens Bros. have constructed a cable destined to carry a current at 20,000 volts. In various workshops motors will be employed up to 75 h.p., and the most varied work will be accomplished by this means. Various experiments will be made on different kinds of transformers, and upon the transmission of force by discontinuous currents. What more particularly will render the exhibition of extreme interest to electrical engineers and the world in general, will be that all the machinery shown will be subjected to carefully made tests, and the results of these tests will be fully published.

Architectural and Enriched Casings.—We have been waiting a long time for the book we have now before us, not knowing when or by whom it would be written. Designs useful, and to a certain extent ornamental, of electric wire casings we have seen from several well-known makers. But a really high-class set of designs of ornamental mouldings specially adapted for interior use in artistically decorated houses we are only just able to acknowledge in the shape of "Architectural and Enriched Casings for Electric Wires," by F. A. Fawkes, of Chelmsford, author of "Architect's Joinery and Its Ornament," published by B. T. Batsford, 52, High Holborn, London; price 2s. 6d. The author, who has evidently made a careful, even a loving study of the art of designing mouldings, mentions he has been applied to at various times for the designs of electric wire casings. He has embodied the best of these designs in the book now published, which is believed to be the first attempt made to systematically introduce architectural skirtings, dado rails, picture rails, and cornices, with grooves and portable covers for carrying electric wires. The designs are of a high order of artistic merit, embodying both severe and decorative treatment of mouldings. Full-sized sections of some 40 specimens of plain casings, with sections of plain and enriched picture and dado rails and cornices are given, while for the more decorative mouldings to assist engineers and architects in the selection, photographs taken from actual specimens are added. We have nothing but praise for this book, which deserves to be in constant use by electrical engineers who have to fit good houses. Some special points in these mouldings are to be noticed—the enrichments are glued upon the wood covers and are made from specially tough composition, not liable to chip or crack like plaster, and when set will take a clean saw cut. The grooves on these casings are made parabolic, a shape taken as offering special advantages for retaining the conductors in place when pressed into the grooves, while also allowing a certain amount of play for inequalities in the insulation. For this suggestion, which certainly seems a useful one, the author is indebted to W. A. Chamen, Esq. A further point is that the covers to the mouldings are all made of sufficient thickness to prevent curling, a too common fault with casing covers hitherto employed. It must be noticed that all these electric casing designs of Mr. Fawkes are protected against infringement.

Great Snowstorm in America.—The fearful snowstorm which prevailed along the Atlantic coast last Saturday night and Sunday morning rendered New York almost helpless. The fall of snow was very heavy, while a high wind prevailed, driving it into high drifts and impeding the traffic in the streets, which, in fact, was for hours completely suspended. All the electric light and telephone wires are down, and the night after the storm not an electric light dependent upon supply companies was burning in the city. The police warned citizens to exercise extra vigilance, as the police and fire telegraphic wires were down, and no alarm could be given in case of fire. The damage in New York alone will cost several millions of dollars to repair, and the injury done in the vicinity must be very great. The city and surrounding country, according to the telegrams, present a scene of desolation in consequence of the storm that is difficult to describe. In the lower part of New York, where the old-fashioned telegraph poles were still standing, the streets are blocked with a number of prostrate poles and miles of entangled wires. Business has been practically at a standstill all day, for all the merchants and brokers have been almost entirely cut off from communication with the outside world. The telegraph companies are the heaviest losers by the storm, as it is estimated that the damage done to the various lines will reach at least half a million dollars. Fifteen hundred wires are rendered completely useless, and it will require at least two weeks to put them in working order again. At the present moment only two telegraph wires are working out of New York, one to Chicago and the other to Albany. All the newspaper and commercial and private wires are down, and the local newspapers appeared this afternoon again with nothing but European news in the matter of telegraphic information, and very little of that. Telephonic communication is almost cut off, as nearly every telephone wire in the city is down or injured. It is estimated that 2,500 of these wires are destroyed, and that the damage to the telephone company will amount to at least 150,000dols. It will take a week or 10 days to put the telephones in working order again. Traffic is almost at a standstill, the snow and subsequent rain, followed by a sharp frost, having made the streets impassable. Telegraphic communication was subsequently restored between Boston and New York, *viâ* Hartford, and the Atlantic cables are working slowly, but improvingly. Further intelligence received of the damage caused, tells that the Western Union Telegraph Company at 10 o'clock that night had 15 wires working to the westward, but possessed no direct communication with the south. They expected to be able to clear off all the business on hand before daylight. The telegraph service in New Jersey and Long Island remain paralysed, but all the submarine cables are working satisfactorily. The snow at Wilkesbarre and in the surrounding districts has been very heavy, causing much damage to the telegraph wires. At Lancaster, in the same State, many of the wires blown down crossed each other and flashes of fire ran along the streets following the broken wires, great alarm being thus caused. A telephone despatch from Harrisburg states that, with a single exception, all the wires connected with that town are down. According to mail advices from Philadelphia, the telegraph service there is entirely crippled. The storm was especially severe between Philadelphia and Harrisburg, great numbers of poles being brought down. Much time will be required to repair the damage done.

DYNAMOS: THE CONSIDERATION OF THE CHIEF FEATURES WHICH REGULATE THEIR APPLICATION.*

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The continuous-current dynamo, which can alone engage attention to-night, consists in its most usual form of a fixed magnet and a rotating armature, separated by a narrow air space. Under the influence of the magnet, the air space between the polar surfaces and the armature core experiences a change of condition, which constitutes what is known as a magnetic field, and the whole activity of the machine is centred in the armature conductors as they revolve in this field. A difference of electrical pressure is constantly maintained along their length, and when their ends are connected through the brushes to the external circuit, so as to form a closed system, a current of electricity is established. The pressure is proportional to the strength of field and to the rate at which the conductors cut it.

If iron filings be sprinkled on a surface placed in front of a magnet, they arrange themselves in lines, having definite directions and more or less densely distributed, in different parts of the field, Fig. 1, whence Faraday derived the conception of defining its strength as proportional to the lines contained in a given area. In a dynamo the field is produced by means of an electromagnet, the construction of which will be familiar to all. The current round the magnet is said to induce the lines of force, or to give rise to an induction, and these lines in turn induce a current in the moving conductors.

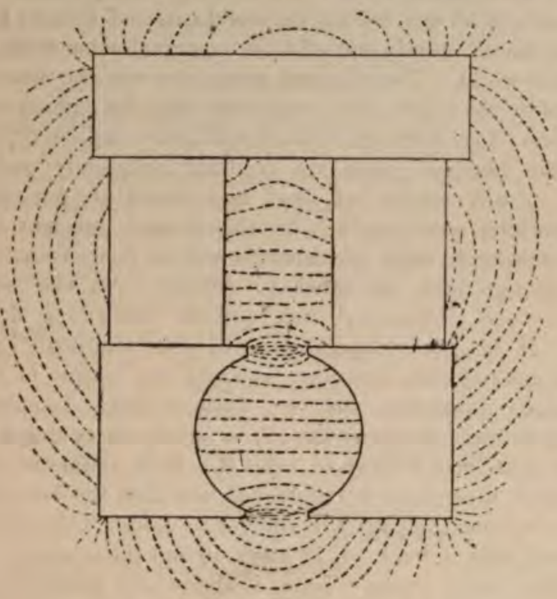

Fig. 1.

The effect which a magnet has on a compass needle, and the powerful way in which it attracts iron from a distance, are well marked evidences that the induction can be transmitted across space, and it is impossible to resist the conclusion, that this can only occur through the agency of a strain of some sort, produced in the intervening medium or dielectric, following the course of a closed circuit running through the iron and crossing from pole to pole, as delineated by the lines of force. Now, a field identical in its properties with this magnetic field, surrounds every conductor along which an electric current is flowing, the lines of force being circular, with the conductor threaded through them. Such a field is essential for the propagation of current, and whatever affects the strength of one also affects the other, consequently, by interlinking a magnetic with a conducting circuit, as is done in a dynamo, and giving them a relative movement so as to vary the number of lines enclosed, a displacement takes place which is in the nature of a flux. The field owes its properties to the dielectric being able to withstand the application of the stress, but in the conductor, as its name implies, the field breaks down, and the power, which has to be continually supplied to build it up again as the conductor moves into a fresh position through the field, is conducted away, to reappear as current energy in the circuit, where it can be either reconverted into mechanical energy by acting on another magnetic field, stored up as latent chemical energy, or dissipated in light and heat.

The effect may be popularly likened to that of a pump employed to circulate water in a closed system of pipes, and it is no more necessary to suppose that the dynamo creates electricity than that the pump creates water. The electricity may be regarded as lying dormant in the system until set in motion by the pressure generated in the revolving armature, when it makes its presence felt by giving rise to what we call an electric current. In the pump, work is done in lifting the water against an opposing head and in overcoming friction, and the measure of the work done in a given time, is the product of the head of water into the quantity. In the dynamo, work has to be done in order to drive current through the circuit against the opposing pressure or resistance, and the rate at which it is done is measured by the product of the pressure into the current. The unit employed for reckoning the pressure is called the volt, and for the current the ampere, and for their product the watt, of which 746 are equal to 1 h.p. The other quantity with which we are concerned is the resistance, which is the name employed to express the opposition to the passage of the current, offered in greater or less degree by all substances; its unit is called the ohm. The product of resistance into current is equal to the pressure, so that loss of pressure, due to resistance between any two points in the circuit, is proportional to the current flowing:

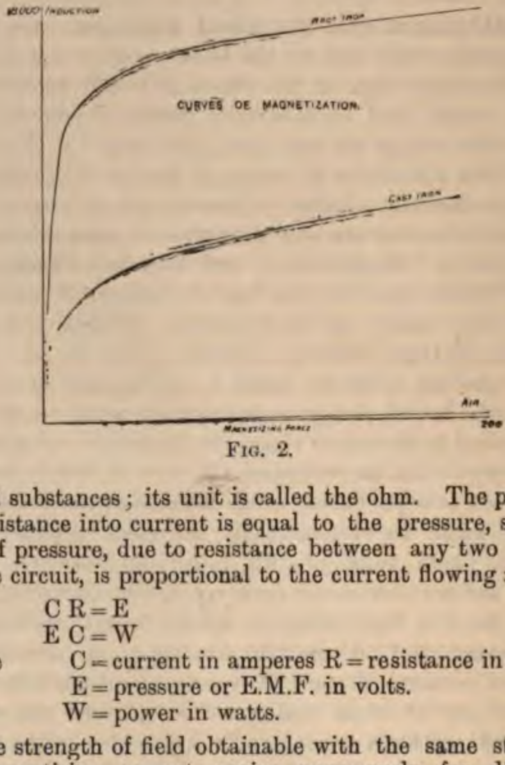

Fig. 2.

$C R = E$
$E C = W$
where C = current in amperes R = resistance in ohms.
E = pressure or E.M.F. in volts.
W = power in watts.

The strength of field obtainable with the same strength of magnetising current varies enormously for different substances. This is expressed by saying that their permeability to the lines of force is different. The permeability of air may be taken as unity, and is independent of the intensity of the magnetising force. In soft iron, with very high magnetising force, the induction may be pushed to over 30,000 lines per square centimetre, but, as shown in the curve, Fig. 2, where the relation between magnetising force and induction is plotted, there is a falling off in the permeability as the magnetisation increases. In iron it is probable that every molecule is already a magnet, but as far as external action is concerned, the resultant force is nil, which Prof. Ewing has recently shown there is reason to believe, is because the molecules under their mutual attractions form groups, in each of which the magnetic circuit is closed on itself. When, however, the iron is subjected to a magnetising force, such as is produced by passing an electric current round it, these groups are broken up, and the molecules tend to set with their axes parallel, so as to form a continuous magnetic circuit through the whole length, with poles at the bounding surfaces of the extremities. The rotation of the molecules is not, however, proportionate to the strength of the current, and to make them assume their ultimate positions, with poles at right angles to its direction, would require an enormously strong current, hence the falling off in permeability.

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* Paper read before the Manchester Association of Engineers

If the path traversed by the lines of force for the whole of their length was through air, as would be the case with coils enclosing no iron, their number would be enormously reduced, and they would be scattered. The coils necessarily take up a good deal of room, so the length of the magnetic circuit has to be considerable, but with iron present, the force is handed on with nearly as full intensity as if all the coils were packed into a thin belt close to the armature, and the length of the circuit proportionately reduced; so that in the dynamo the part performed by the iron is one of concentration.

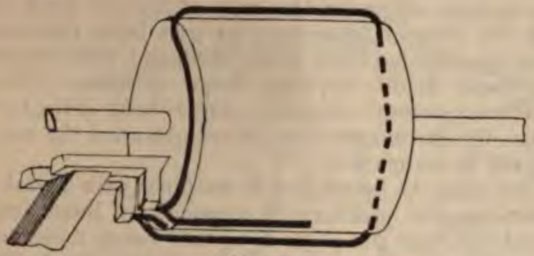


FIG. 3.

All armatures are built on one or other of two fundamental types, the drum, Fig. 3, in which the conductors are all wound externally, and the ring, Fig. 4, in which they envelop both inside and outside of the iron core. As the connections for each are analogous, it will suffice in tracing the action to select the ring winding as an example. A core is built up of thin iron rings, electrically separated from each other by means of such material as paper; this is done to prevent heating due to currents which, if it were composed of a solid mass, would circulate through the length. By means of a non-magnetic spider frame, this core is secured to the rotating shaft. On it are wound the insulated conductors, in the form of a closed spiral, the external part of every turn of which cuts the magnetic circuit twice in a revolution, the impulses of each turn being added. The ends of each section of the spiral are connected to a pair of commutator bars, on which the brushes rest, and by which communication with the external circuit is established.

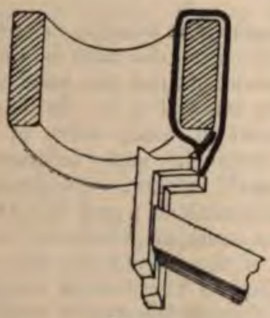


FIG 4.

The commutator is built of bars of copper insulated from each other, and the brushes are set to bear on diametrically opposite sides; each bar in turn is brought into action twice in a revolution, and conveys the current alternately in a positive and then in a negative direction, as it passes under the brushes.

The direction of the current in the conductors is shown on Fig. 5 by means of arrows, and the commutator bars, which for sake of clearness are reduced in number, are shown with their connections, the sections being defined by the portions contained between contiguous bars. It will be seen that the currents in each half converge at the brushes, and as each section belongs first to the right and then to the left, two impulses are given to it in each complete revolution. As the armature revolves, the sections now belonging to the side marked south pass to the side marked north, and below in the reverse order. The lines of force, which cross between the poles and the armature, are cut by the conductors on the right from below, and on the left from above; hence on either side the currents will flow in opposite directions round the spiral, the two streams entering the brush in the same direction.

These currents surrounding the iron core necessarily magnetise it, and the polarity which they impart differs in direction to that of the field magnets. The two sets of lines of force are superimposed, with the result that a fresh distribution of field is produced, Fig. 6, and the line dividing the core into two halves, across the diameter at which the lines of force enter from one side and emerge from the other, which is called the neutral line, is now oblique to the plane of symmetry. Changes in the strength of the current cause the position of the neutral line to change. The brushes, to work without sparking, have to be set a little in advance of it, and when its position changes the brushes have to follow suit. This occasions the chief need for attention in working the machine, as there is always excessive wear of the commutator when the brushes are improperly set, and an accurate comprehension of what takes place is of material assistance in the management. In Fig. 5 the section shown is just on the boundary between the lines of force entering the core on one side and emerging on the other, where the field is nil, so that comparatively little difference of pressure exists between contiguous bars, and the section has just been closed on itself by the two commutator bars being bridged by the brush. Up to this point the section has been carrying the same amount of current as all the other sections on the same side which are in series with it, but now being momentarily short-circuited, the strength and direction of current will depend on the field through which it is passing. To prevent sparking, the brush has to be set in advance of the neutral line, at the point where the density of the field is just sufficient to stop the current, and raise it in the opposite direction to the same strength as that flowing in the coils on the side to which it is just passing. Now, in virtue of the property of self-induction possessed by an electric current, which is greatly augmented by the presence of iron in the core, and which is analogous to the inertia of a ponderable body,

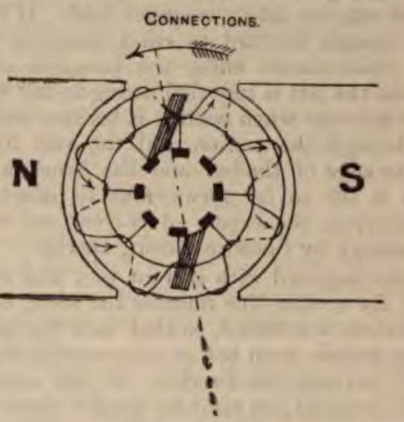


FIG. 5.

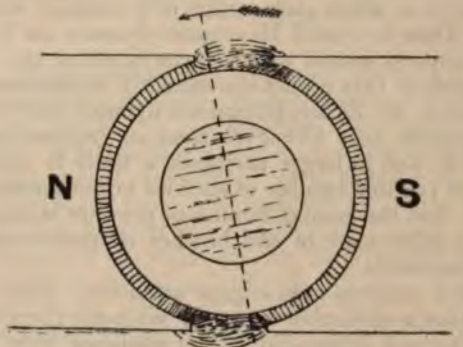


FIG. 6.

the current contains a small store of energy, and this has to be given up before the current can be stopped, and in raising it again in the opposite direction, energy is absorbed, both in consequence of the self-induction and the resistance of the section. The amount involved varies as the square of the current strength, therefore, with heavy load, a stronger reversing field is required It, however, unfortunately happens that the obliquity of the field due to the armature reaction increases with current in a direction which leaves the brush in a weaker field, whereas a stronger one is wanted, hence, when load is added, it is always necessary to advance the brushes in the direction of rotation into a stronger field. If they are not placed far enough forward to effect complete reversal by the time commutation ends, the progress of the main current from the left is impeded owing to self-induction, so that at the moment when contact is broken part only finds its way through the section, and the rest forms an arc between the edge of the bar and the brush, and again, if the brush is set so far forward as to effect more than complete reversal, the excess of current set up can only spend its energy by likewise causing sparks.

In a motor supplied with current in a like direction, the position of the neutral line remains the same, but the direction of rotation is reversed, so that now the action of the field on the section, even before commutation commences, is tending to reverse the direction of the current. The sequence of assisted and retarded motion remains the same as in the generator, and the brush has still to be set on the same side of the neutral point, the lead, as the displacement of the brush is technically called, now becoming negative, and will have to be increased with load in the direction opposed to the rotation.

No machine has hitherto been constructed with an absolutely fixed position for non-sparking point, but to a great extent it is under control by proper shaping of the pole-pieces and by increasing the strength of the field, when as fewer turns of the conductor on the armature are required to produce the pressure, the obliquity of field and self-induction are reduced. The energy of the spark can also be diminished by multiplying the number of sections; in small machines this can be pushed to the point at which the commutator bars become so thin that a brush of proper thickness to collect the current without heating would bridge more than two bars at a time, and in large machines to the point at which each section only contains one convolution. Thus in a small Manchester dynamo for 100 volts and 24 amperes wound with 480 convolutions, the number of commutator bars cannot conveniently be increased above 40, whilst in an Edison-Hopkinson dynamo for 105 volts, 1,100 amperes, only 43 convolutions are required to obtain the E.M.F., and in larger machines a limit is reached at which the possible number of sections in the commutator is so small, that the great difference of pressure between them makes an adjustment of the brushes to prevent sparking almost impossible.

The field magnets next engage attention. They may be made either with double or single magnetic circuit, as the Manchester and Edison-Hopkinson machines, Figs. 7 and 8. The single circuit is the most simple, and will best serve for illustration. The best results are obtained with wrought iron, because, as may be seen from Fig. 2, more intense magnetisation can be obtained with less expenditure of force. This, however, chiefly resolves itself into a question of cost and expediency. In some machines cast iron is exclusively used, and in some, as the Manchester, there is a composite circuit. In the Edison-Hopkinson only the softest annealed wrought iron is used throughout.

The lines of force in passing from pole to pole choose the path of least resistance, only those penetrating the armature core being effective. Owing to the small distance between the core and the polar surfaces the major portion pursue this course, but inevitably some, emanating chiefly from the outside of the pole-pieces, pass external to the armature and are wasted, and if other masses of iron, such as the bed-plate, are in too close proximity, an undue number may be lost, and even in the best designs the amount is from 20 to 25 per cent.

The larger the section of the armature core in proportion to that of the magnet the less strongly it will be magnetised; it attracts more lines and reduces the waste, but the increased quantity of iron enclosed by the armature conductors tends to increase the obliquity of the field, so that less current in proportion can be carried, and it is therefore desirable to take a mean value; this, when only wrought iron is used, is arrived at when the permeability of the armature core is only slightly greater than that of the magnets.

It is undesirable, on the score of economy, to saturate the iron by magnetising it beyond the point at which the permeability begins to fall away rapidly. On the other hand, if the induction is too low, any irregularity in load or speed is liable to produce magnified fluctuations in the pressure.

It is important that the bored faces of the pole-pieces should embrace the greater part of the circumference of the armature, otherwise the area of the air space across which the lines of force have to pass, being restricted, a greater magnetising force is required, and there would be more waste field. In very large machines, however, restriction becomes a necessity; for without it the balance between the current-turns on the armature and the magnets could not be maintained.

It will often be found that in machines with a weak field the tendency to sparking is corrected by increasing the interval between the polar tips, this being necessary to ensure proper gradation of field for reversal, but the lead is then considerable. In the Manchester dynamo, in which the field is powerful and the air space small, the reduction in the gap between the tips to 5deg. or even less decreases both speed and lead. In this case there can be little doubt that the leading convolutions of the section under commutation enter the field on one side of the neutral line before the rear one emerges from the field on the other side, and so reversal is expedited, and the lead varies less with different loads.

The number of current-turns required to give the same magnetisation to iron is proportional to its length, no greater length of magnet limb should therefore be used than is consistent with a sufficiently shallow winding to allow the heat to escape. The proportions of Edison's 60-light dynamo, as brought over to this country nearly 10 years ago, was referred to, and the reduction in length of the field magnets made by Dr. J. Hopkinson, whereby, still using nearly the same weight of copper, he was able to produce a field of so much greater strength that it permitted of a fresh arrangement of the armature conductors, and the machine gave double the output.

Two different methods of winding magnets are employed. For series-wound machines the main on its way to the external circuit is carried round the magnet limbs, using a thick wire with few turns, Fig. 7. In shunt winding, Fig. 8, a separate circuit of many turns of fine wire proceeding directly from the main terminals is employed, carrying only a small current. Compound winding is a combination of both methods; each has its special applications, but in all the same magnetisation is produced, provided the product of the current into the number of turns is constant. Owing to the loss of energy which takes place in sending a current through a conductor against its opposing resistance heat is always generated, and the dimensions of the wire have to be proportioned accordingly. In series winding the length is determined by the number of current-turns required, and the section by the strength of current. In shunt winding there is for every machine a proper diameter of wire proportional to the linear dimensions and to the E.M.F. which gives the right number of current-turns, but the length is arbitrary. If it be doubled, the resistance is doubled, and the current, therefore, halved, but the total current-turns remain nearly the same. In practice the length is therefore determined solely by considerations of economy. With the longer wire there is less loss of energy, and, therefore, less heating, but increase beyond a certain length is prohibited by the expense. For small machines, where the radiating and conducting surfaces are proportionately large, and the depth of winding small, the heat can readily escape, and 2,500 yards to 3,000 yards for every 100 volts at the terminals is sufficient. In large machines, especially when high efficiency is aimed at, double this length is sometimes used.

Of the total pressure generated, part is absorbed in overcoming the resistance of the armature and the magnet winding, the rest being available at the terminals for use in the external circuit. With increased load more energy is required to drive the increased current round the armature, and at the same time the reaction on the magnets is increased, those coils included between the brush and the line dividing the armature symmetrically between the poles, act in direct opposition to the magnet coils, tending to weaken the field, whilst the remainder tend to twist it. And the greater the twist the greater the lead, so that unless the magnetising force or the speed is increased, the presure at the terminals must fall as load increases. In the shunt machine this occurs in threefold manner, as the reduction of pressure at the terminals, consequent on the armature loss and the lead, results in less current being driven round the magnets. The effect in the series machine is different, the pressure being augmented, because the magnets being excited by the main current increase in strength as it rises.

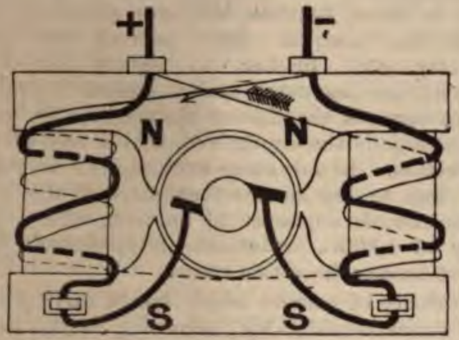
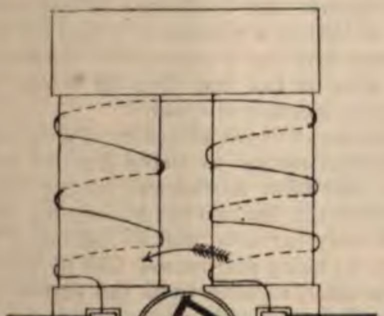


FIG. 7.

In Fig. 9 the results for constant speed are plotted. The volts in the shunt machine fall, whilst those in the series rise as the current rises, by employing compound winding the mean of the two effects is obtained, and the volts can be kept practically constant over a wide range, without change of speed. By proper proportioning, the pressure can be made to rise slightly with increased load, and the fall in speed of the engine, which to greater or less degree occurs wherever mechanical governors are employed, can be compensated for, and even the varying loss of pressure with different loads in a long main conductor is under control. It is not, however, possible to compensate exactly in such cases as lighting circuits, where some lamps are close to the dynamo and some far away.



In machines in which the convolutions on the armature are excessive, it is necessary that the series winding bear a large proportion to the shunt, in order to compensate for the loss of pressure due to high resistance and the obliquity of the field, but where the magnets are relatively powerful the correction is small. For example, in a Manchester dynamo for 100 volts and 320 amperes, the series coils at full load contribute 45 per cent. of the whole magnetising current, whereas in the Edison-Hopkinson for the same output it is only 20 per cent., from which it follows that in the latter the lead is less variable.

In the series dynamo, up to the point at which the magnets become saturated, the current and pressure grow together, beyond this, supposing the speed to remain constant, the waste field and the loss due to armature resistance are both increased by the greater current, so that at the terminals the E.M.F. will begin to fall away again.

The chief uses of the series machine are for motors, or for high tension for arc lights, worked in series. As a motor, where it has to be started and stopped with the load on, the resistance of the magnet coils added to that of the armature moderates the flow of current when switched on. There will, however, be great changes of speed with variable load, unless a regulating resistance is applied. For the propulsion of locomotives the series-wound motor possesses the advantage of exerting a very powerful torque at slow speeds, as the back E.M.F. generated is then small, which not only adds to the force of the armature but also strengthens the magnets. For arc lights the magnets should be well saturated, otherwise fluctuation in pressure and current occur with every variation in the resistance caused by the distances between the carbon points changing; when these close there is a rush of current which with non-saturated magnets would be still further augmented by increase of pressure, due to the consequent increased excitation, and this acting on the mechanism of the lamps would unduly separate the carbons, causing in turn an excessive fall of current.

In the shunt dynamo variation in load, as already explained, causes considerable variation in pressure in the inverse sense. Where constant pressure is required as in supplying incandescent lamps, compound machines are therefore generally employed, but where intended to run in parallel, and where changes of load are small or the engine governor is not sensitive, shunt machines answer as well. For charging accumulators they are necessary, as if by slipping of the belt, or other cause, the pressure falls below that of the opposing E.M.F. of the cells, the current runs back into the dynamo, making it run as a motor. This, however, in the shunt machine tends to increase the speed, and checks excessive discharge, but if it were series wound the polarity would be reversed, and it would generate current in the same direction as that flowing from the cells, causing a violent discharge to the detriment of both. A shunt-wound motor can be run at approximately constant speed with either full load or no load, but care must be taken to avoid such overloading as would bring it to a stand, when by all back E.M.F. being done away with excess of current would injure the armature.

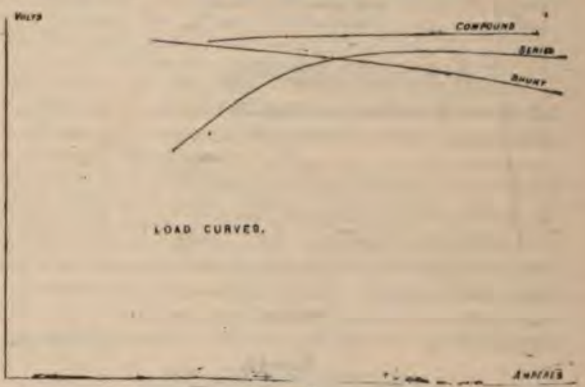


FIG. 9.

In a dynamo at rest there will be little, if any, magnetism. After starting, excitation depends on an infinitesimal current from the armature reinforcing the field, whereby a further increment of pressure is established, and the mutual reaction soon raises the strength to the full limit. The time required depends on the residual magnetism and on the proportion of iron to copper, and may vary from a few seconds to many minutes, being greatest in a new machine. For every speed there is a point at which the product of the current into the resistance creates an opposing force equal to the pressure generated by the armature, and no further rise of pressure can take place without increase of speed. In a series machine, as excitation is effected by the main current, the circuit must of necessity be closed, but in the shunt machine, if the main circuit be closed at starting there will often be a difficulty in exciting, unless the speed is temporarily raised above the normal, for owing to the path of low resistance offered by the main circuit, the pressure at the terminals is pulled down, and less current flows round the magnet circuit. In the compound machine, as both sources of excitation are employed, it is generally best to keep both circuits closed.

When it is desired to change the direction of rotation, the lead of the brushes has to be changed to the opposite side of the neutral line, and their inclination reversed, so as to prevent them tripping against the commutator. It is also necessary to change over the connections of the magnet coils (which is most conveniently done by crossing the leads from the brushes), for as the armature conductors now cut the lines of force in the reverse direction, the positive and negative sign at the brushes is changed, and if the connections were unaltered the reversal in the armature would change the polarity of the magnets, which would again reverse the flow in the armature, and so on *ad infinitum*. It follows, that while it is immaterial which pole be north and which be south, there is only one way of connecting up for each direction of rotation with which the machine will work.

When working with the same induction, the proportion of copper to iron in various sizes of machines will remain approximately the same, and with the same peripheral velocity the outputs will be nearly as the weights. Fig. 10 shows the general form of the curve for various sizes of Edison-Hopkinson machines, for from 12 to 150 e.h.p. It should, however, be noted that in the case of the larger machines, the curve of actual velocities is drawn to suit direct drive off the shaft of such engines as those of Messrs. Willans and Robinson, otherwise velocities 25 per cent. greater would be admissible. It is not desirable to stint the copper, but it should be so disposed that the energy lost is a minimum; for this purpose, on the armature there should be a few turns of large section, and on the magnets greater length or section, according as they are shunt or series wound. These conditions can, however, only be fulfilled when the iron is also plentiful. If it were not the same quantity of copper might still be employed, but with diminished efficiency, and it can only be in special cases, where light weight is of greater importance than either efficiency, durability, or cheapness, that little iron can be tolerated.

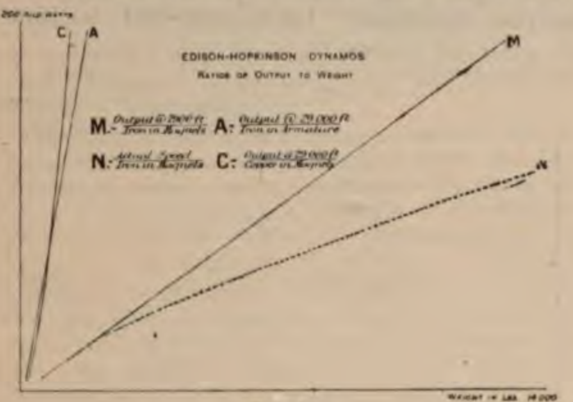


FIG. 10.

The load which a dynamo will carry is limited either by such strength of current being attained that any increase would cause a rise of temperature injurious to the insulation of the conductors, or else by the obliquity of the field and self-induction becoming so great as to prevent proper reversal in the sections under commutation. The load is therefore greatly dependent on the relative section of the magnets and armature and current-turns on each, the number of the latter being affected by the resistance of the air space.

In the drum armature the self-induction is least, whilst in the ring the ventilation is generally better, the result being that for small machines, electrically, there is little to choose between them, though for these and for high-tension machines there are points in the construction of the ring which have special advantages.

In the drum, as the coils overlap at the ends, if the insulation of a section fail it is generally necessary to rewind the whole; and also owing to the overlapping there may be great difference of pressure existing between contiguous wires, tending to produce short circuits. In the ring armature each section is separate, so that short circuits are less easily produced, and repairs more easily effected. For large sizes, however, induction troubles are greater, and as large drum armatures can be wound with a different arrangement of end connections and in a more symmetrical form, by using spiral strips, they are to be preferred. The round conductors are replaced by bars which allow of a larger section of copper, as the insulation takes up less room. It is necessary to make the bars thin on the face in order to prevent undue heating, caused by local currents started in them, between opposite sides as they pass through the unequal field between the polar tips. Frequently, still further to reduce loss from this cause, they are laminated, and a gradual widening of the air space towards the tips of the magnets, by preventing abrupt change in the strength of field is also efficacious in this direction. In a dynamo working with an induction of 12,000 lines to the square centimetre, if the width of a solid bar exceeds a quarter of an inch, with a peripheral velocity of 1,800ft. per minute, it is difficult to prevent excessive heating from this cause.

The density of current which can be carried by a conductor varies considerably, according to the intensity of these eddy currents, the conditions of temperature under which the machine is working, length of runs, depth of winding and section and means for ventilation. No general rule can therefore be given, as it may vary from 1 to 2·4 amperes per square millimetre in the magnets, and 2·5 to 6 in the armature, but it is not difficult, from experience in a few cases, to determine the proper size for any particular winding.

In selecting a machine it is always desirable to ascertain what is the rise of temperature to be expected after working. It used not to be uncommon to find machines with armatures which heated to nearly boiling point of water, and though many have lasted for years, there is always a gradual decay of the insulation going on, which, together with expansions and contractions of the metal and working strains, finally loosen the conductors in their places. The tendency has been constantly to reduce the temperature, and the Admiralty specification, which is intended to cover the most trying conditions, limits the rise to 40deg. F. Such a low figure, however, entails a very expensive machine, and for general purposes fully double this rise may be permitted without any risk whatever. Rise of temperature in the armature also has the effect of reducing the pressure, because the coefficient of resistance of copper increases, so that in a machine in which the current density is high there may be a perceptible difference in the performance after it has had time to warm up, which will necessitate an increase of speed.

The commercial or net efficiency of a dynamo is the ratio of the electrical energy, available for use in the external circuit, to the total mechanical energy absorbed. The difference between the two being made up of losses due to friction, to eddy currents, and to heating of the armature core due to its being magnetised first in one direction and then in the other, together with the further losses due to armature and magnet coil resistances.

The electrical or gross efficiency is the ratio of the power available in the external circuit to that part of the energy transmitted by the belt which is converted into electrical energy—that is, to the electrical energy in the external circuit plus whatever is lost in overcoming the magnet and armature resistances. In the earlier machines the losses from all these sources, especially from armature resistance, were so high as often to reduce the net efficiency to below 60 per cent. In recent machines it is rare to obtain a return of less than 80 per cent., and in the best machines it amounts to over 90 per cent., sometimes reaching 95 per cent., but small machines, or those run at very slow speeds, cannot be expected to give so high a return, as the resistance of the armature conductors will be high. For this reason it is only for the sake of coupling direct to the engine shaft, thereby gaining in compactness and absence of belting, that very slow speeds are much employed. Very high speed, again, possesses the same disadvantages common to its use with other classes of machinery, and a velocity of from 1,800ft. to 3,000ft. per minute at the periphery of the armature is now commonly adopted.

The mechanical strains which are likely to be injurious are confined to the armature. The chief one is the stress on the conductors, tending to make them slide on the surface of the core. In small machines bands of brass wire wound closely round the circumference produce sufficient adhesion to keep them in place, but in large machines it is desirable to provide a positive means of driving, for which purpose radial metal pegs can be let into the core. A considerable factor of safety is required in all parts of the armature, because accidental short circuits in the external circuit are liable to cause sudden rushes of current, producing enormous transient strains, which may cause the conductors to be displaced, and may permanently strain the shaft. The latter effect is specially liable to occur in machines in which, owing to the shape of the pole-pieces, the magnetic attraction of the core is not equally balanced. This is a defect sometimes found with single-circuit dynamos in which the section at the extremity of the poles is much reduced by being tapered off. The armature may then be attracted towards the magnets with a pull amounting to many times its own weight, and even under normal conditions of working, this is liable to make the bearings heat. It can, however, be remedied by placing the armature eccentrically in the fields, so that on the side where the pull would be greatest the air space is increased. There may also be end-pull if the core projects unequally beyond the bore of the magnets.

The materials at our disposal for insulating purposes are divisible into those which are rigid or flexible, combustible or incombustible, damp or oil proof, or the reverse. All the most useful qualities cannot be combined in one material. For the insulation of the commutator it is difficult to imagine anything more suitable than mica; its price is, however, too high, and it is not sufficiently flexible to be applicable for all purposes. Fibrous materials, treated with varnish or indiarubber, are almost compulsory for the insulation of the conductors. These will withstand as high a temperature as, on other grounds, it is at all desirable to permit, and with care and cleanliness may last for years. There is, however, no denying that, owing to their yielding and absorbent nature, they form the weakest link in the structure, and any small leakage set up is rapidly extended, owing to the charring of the material. Possibly in the future the skill now so abundantly brought to bear on the production of artificial substances will place fresh materials at our disposal. In general design the dynamo has arrived at a stage at which little radical change can be expected. The efficiency is already so high that increase is scarcely possible, and, as far as consideration of cost of power is concerned, a difference of 5 per cent. one way or the other is rarely of much importance, but seeing that a high efficiency is accompanied by a reduction in heating, in sparking, and undue strains generally, it betokens a thoroughly sound and reliable machine, requiring the minimum of attention, and, therefore, to the purchaser carries with it a warranty of satisfactory performance.

Future improvements will probably chiefly consist in details of construction, labour saving in production, and perhaps new and less perishable materials for insulation. Abolition of the variable sparking point is the most important problem which remains to be solved. In working, the dynamo will not stand neglect or unskilful handling, and amply repays a moderate amount of care bestowed on it.

I have to express my thanks to Messrs. Mather and Platt for the facilities which they have afforded me at their works for the preparation of this paper.

GARRETT'S MAGNETO BELL.

Magneto-electric bells have certain well-known advantages over ordinary electric bells, but of these perhaps the most eminent two are that they are practically everlasting, and that they do not develop faults in the line to which they are connected, since the E.M.F. is only applied to the line when they are in actual use.

We herewith illustrate a new magneto-electric bell, patented by Mr. T. A. Garrett, constructed by Mr. James Pitkin, of 56, Red Lion-street, Clerkenwell, E.C., which probably will come into extensive use, having many qualities to recommend it. It is of strong construction and well adapted to stand the somewhat rough usage which such bells inevitably meet with when placed in the hands of the public. From the simplicity of its construction we imagine it will be manufactured more cheaply than any other magneto bell we have seen. This simplicity has not been obtained by the sacrifice of loud ringing; in fact, it seems to us to be louder than other magneto bells. We understand that a very great number of experiments have been done in making this bell simple and loud.

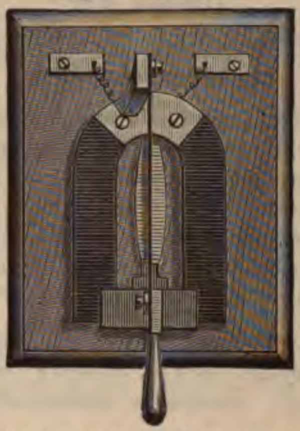


Fig. 1.—Garrett's Transmitter.

The transmitter consists of a single horseshoe permanent magnet, between the limbs of which there is a soft-iron core wound with wire, and a spring carrying at its free end a soft-iron armature, which can vibrate over the poles of the magnet and the end of the iron core. When the armature is pulled aside and let go it vibrates to and fro, and in so doing acts on the magnetic field so that an alternating current is generated in the wire round the iron core.

The transmitter and receiver are very similar in construction, the chief difference being that in the receiver the armature consists of two pieces of soft iron which are both attached to the spring, but one of these is magnetised only by the north pole of the permanent magnet, while the other is magnetised only by the south pole, and the ends of these pieces of iron are so bent that they are near to the end of the soft iron core but on opposite sides of it. When a slowly-alternating current is passed through the wire surrounding the iron core each of the pieces of iron forming the armature is alternately attracted and repelled by the end of the core, and since one is being attracted while the other is being repelled the armature moves as a whole from side to side, and carries with it a hammer which hits a bell. Since the cores in both the instruments are stationary, there is no necessity to have flexible connections, and consequently there are no loose wires which are liable to be broken.

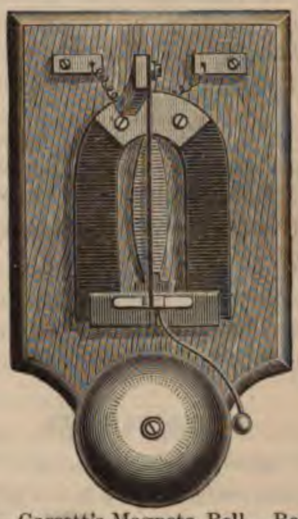


Fig. 2.—Garrett's Magneto Bell.—Receiver.

The circuit is always complete, therefore if this bell is used in a mine there will be no danger that a spark may cause an explosion. But probably the most extensive field for it will be in connection with telephones, and its arrival at the present time is most opportune, owing to the expiration of the telephone patents, and it should prove admirably adapted for ordinary house work.

THE

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THE POSTAL TELEGRAPH DEPARTMENT.

The work of this department being under Government control, cannot be subjected to the close observation that is given by competitors to ordinary manufacturing processes. The general public base their opinion as to the efficiency of the department upon the manner in which they are individually served. A few people are able to compare our telegraph system with those in vogue in America and on the Continent. Those who can make such comparisons are almost unanimous in favour of our own department. The service is admitted to be about the best in the world. A little examination into what such a statement means will show that to obtain this position not only must the *personnel* of the department be good, but the instruments and apparatus used must be the best of their kind. The progress in modifying instruments and in perfecting the organisation is unseen to the outsider. Now and again a report in a Blue-book tells of this progress, but usually the Blue-book is put into the hands of the public at a time when its contents to the workers in the department savour of ancient history. We have been able to glean a fair history of the more recent work in the department, some of which may be referred to without interfering with red-tape regulations. We have already referred to the experimental telephone line in progress between London and Paris, but it may be news to some of our readers that the electrical branch of the department has devised a new telephone said to be equal to the Gower-Bell instrument. A number of minor improvements, each of which, of course, tends to make telephonic apparatus more perfect, have been introduced. Thus, seamless flexible tubing is used for the hearing tubes in the Gower-Bell instruments, a non-polarised relay has been devised and introduced at Newcastle, as has a new handle switch and an adjustable elbow rest, also non-polarised indicator relays, switchboard telephone tablets, etc. Improvements have been made in the details of the Newcastle multiple switch. Experiments have been made with a new form of induction coil; and a variety of apparatus has been subjected to careful trial, though in the majority of instances it is found that such apparatus is no better than what the department has in use. Thus it will be seen the official world has been kept thoroughly conversant with the possibilities of telephony. Direct communication has been held between London and Glasgow over the new 200lb. copper wires.

There is no doubt about the progress of the Telegraph Department. Year by year greater demands are made upon their circuits. These demands have to be met, sometimes by arranging new circuits, sometimes by introducing new apparatus, sometimes by modifying the old apparatus. Thus, by modifying the apparatus the speed of working the Irish cables has been increased from 25 to 30 per cent.—in other words, while 200 or 230 words used to be sent, 250 or 300 are now sent. Elsewhere, we reprint from the *Times* a full account of the changes in communication with Germany introduced by the department since the work came into its hands. Improvements, simple in themselves, are being constantly introduced; thus a long series of experiments has resulted in the design of a satisfactory arrangement for use at repeater offices, by means of which the sounders are normally silent. The value of this will be better understood by the initiated than by the outsider. Formerly the sounder was not usually silent, and the call was not always effective at once. From silence to sound should arrest attention immediately. Improvements have been introduced with all kinds of working—simplex, duplex, quadruplex, and multiplex—so that the speed of signalling is gradually increasing all round. It will be seen from these brief remarks that the officials are constantly alive to the necessities of the age, and no effort is spared to keep the telegraphic system in the highest state of efficiency. It must be remembered also that economy has to be considered as well as efficiency, and in the attempt to find some substitute for platinum many experiments have been made with various metals and alloys, as have experiments upon the quality of steel used for magnets, the latter of which led to the conclusion that the steel from French makers was better for this purpose than the steel from English makers. Altogether the officers of the department are to be congratulated upon their energy, activity, and, from the public point of view, their success.

A NEW PERIL.

Such is the title of an article in the *Speaker* of January 24, following the lead of *Nature*, and some of our technical contemporaries. The boom may be termed the Kensingtonian condemnation of electric and other railways that may or may not interfere with their very delicate instruments and investigations. No doubt it is a bother to be troubled with these necessary works of modern civilisation, but they are works we cannot very well do without; while the professors can at any rate move elsewhere, or, if they remain, take a few precautions over and above what they take now. It seems to have become an unpleasant and an unwelcome duty for us to point out little lapses of Kensington. If not, why was the *Speaker* brought to us, marked, and with a request to notice? We are compelled to say that of all the statements made with regard to the damage to physical laboratory work, there is but a grain of truth in any of them. We would undertake to erect a laboratory in, or over, or under Paddington Station, and let the whole Great Western traffic be run electrically without troubling one iota, or measurements being affected in the slightest. We have been told of the troubles arising from vibrations caused by walking. Is there a single man of scientific repute that does not know the cure? If not, let him sleep in a hammock and consider. Exterior "magnetic tornadoes," as the *Speaker* calls them, are to be rendered as harmless as the autumn winds of Vallombrosa to the towers and turrets of the Spanish castles. The *Speaker* goes on to say: "Nothing but an overwhelming public necessity should be allowed to interfere with these institutions on which private funds have been lavishly spent for the public good. If their claims are ignored, the possibility of offering a good scientific education to the sons of middle-class and working men is endangered."

This is sheer unmitigated nonsense, and if such statements are made authoritatively by the South Kensington or any other interested people they are stating what is absolutely untrue, and they know it. The world of business is not going to stand still because certain delicate electrical measurements are to be taken. In the first place, few, if any, such measurements are required in "the teaching of the sons of middle-class and working men." They are, perhaps, required in the experimental work of the professors, but money is not subscribed to allow a few enthusiasts to investigate into any and every direction their fancy leads them—the money is subscribed for the teaching of the "sons of middle-class and working men."

Again, the *Speaker* says: "A proposal has been made to run a subway between South Kensington and Praed-street, and powers to propel the trains by electricity are asked for. The course marked out for the line runs under one of the physical laboratories of the Royal College of Science, and is separated by the breadth of the road only from the others. It is also to pass within a few yards of the City and Guilds Central Institute for Technical Education. That the line might be in some respects convenient is quite possible; that if the powers to employ electricity are granted and used as at Stockwell, existing physical laboratories will be rendered useless, is certain. The South London line is surrounded by an iron tube which acts as a 'magnetic screen' and serves to diminish its magnetic effects on external objects. No such precaution is, as far as we are aware, to be adopted at Kensington, and in this respect, at all events, the proposed line is likely to be the more injurious of the two. To the laboratories of the Royal College of Science teachers are brought by Government funds from all parts of the country. Every summer 200 come from far and near to hear lectures and to go through a course of laboratory work."

We should like to point out that the majority of these 200 science teachers brought up from the country to be taught, probably have nothing at all to do with delicate electrical apparatus. Some are chemists, some are mechanics, some are mathematicians; some are students in one subject, some in another, and only one small portion are "electrical." Suppose the railway company, for the sake of these few, puts up a "magnetic screen," no doubt all the experiments required by the "science teachers" could be performed.

After saying this much, we will admit that if the opposition to the electric railroad had contented itself with statements of fact and truth, their case would have been stronger, but no such attempt has been made. What has been done has been an attempt to lead the public to conclusions by means of statements that are untrue. A considerable expense might be incurred in making the laboratories fit for delicate experiments if the railway is proceeded with, and that expense should be borne by the railway if its promoters did not alter their plans, but to say that such a railway would practically neutralise the value of South Kensington as an educational establishment is absurd. The majority of students there have nothing to do with delicate measurements—they have nothing to do with electrical measurements at all; and the "sons of middle-class and working men," even if they are students of electrical subjects, do not require measurements of the amazing delicacy suggested by the *Speaker*.

OVERHEAD WIRES AGAIN.

The recent snowstorm in America has once again demonstrated the difficulties that must arise from the continued use of overhead wiring systems in large towns. The *Times* telegram of Monday, from New York, said: "All the electric light and telephone wires are down, and last night not an electric light dependent upon supply companies was burning in the city." It is hard to credit such a sweeping statement, as we all know that while overhead wires are common, a good deal of underground work has been carried out. But if the damage to electric light wires is bad, that to telegraph and telephone wires is worse. Practically, telegraphy and telephony in the district swept by the storm is at a standstill, and the cost of renewal will be enormous. The intermingling of electric light, telegraph, and telephone wires caused phenomena described as "balls of fire ran along the streets following the broken wires." It may be a source of gratification that nothing worse than arcs in the streets were observed, when many fires might have been caused and lives lost. So far as human knowledge goes, there is no country or district upon the face of this world but is at times subjected to storms sufficiently strong to cause great damage to overhead wires. Especially is this danger to be considered when we know that such wires are run for purely economic reasons. The initial cost is far less than the cost of underground work, but a few more such disasters as befell the telephone wires in London a few years ago, and now have to be deplored in New York, will go far to prove that in the long run it is cheaper and better to adopt an underground scheme from the first. Where initial cost rules the question, overhead wires are certain, and it is as certain also that those overhead wires will be put up as cheaply as possible. Promoters and managers are too prone to consider the present, and to trust to luck for the future, than to expend a larger amount to attempt to ensure future safety. We have never been convinced but that investors would agree to provide the extra capital if the matter was properly put to them. With one or two possible exceptions investors are tempted to invest by means of promises, promises that can only be fulfilled under most exceptional circumstances. The annual cost of maintenance of these overhead systems is, we believe, considerably in excess of what would have to be similarly paid for underground work, and the annual outlay thus saved would go a long way to pay the dividends on the extra capital initially required. All these things have to be considered from the £ s. d. point of view. Pure science may say this, or may say that, but those who run companies care only for the statements of science so far as they will gull the investing public. The sole question, then, is, will the annual savings in maintenance, and the periodic savings because of general breakdowns, suffice to pay dividends on the extra capital required to prevent this increased cost of maintenance and these breakdowns? We contend that in all thickly-populated centres the extra outlay is warranted.

MEASURING MAGNETIC RESISTANCE.

We have taken up a position stated in several articles lately written differing considerably from the present conception upon the theories, more particularly as affecting practice, of magnetic action in iron. We have preferred to consider the whole effects in a magnetised body of iron as a magnetic circuit, with functions and simple laws comparable to those of a conductive circuit and Ohm's law. We have further suggested the preparation of a set of standard magnetic resistances, similar to those now standardised in the ohm, etc., so that manufacturers can prepare their manufactures to specification as copper is now prepared, and could guarantee their iron as of so much per cent. magnetic conductivity for a certain standard, shape, and section. We are pleased to learn that a large manufacturing firm in the North have commissioned one of our best-known electricians to test and report upon 50 different specimens of iron for dynamo magnets of different composition and processes of manufacture, so as to enable the said firm to undertake orders and guarantee their iron. The whole electrical profession will take a keen interest in such an attempt to deal practically with this most important electrical problem, and the example thus set will no doubt be imitated, and from the results obtained a practical standard may be evolved. We are not aware in the proposed tests whether our suggestion for magnetic conductivity is to be acted upon, or whether, as is most probable at present, the tests will be taken along the lines of ordinary theories. We shall be interested to be informed in what units the measurements are to be made; whether permeability, hysteresis, and the rest are to be separately tested, or whether the magnetic conductivity as a whole is to be taken. We should like to know whether the magnetic conductivity will be taken at limits the section can carry well, and whether the overloaded iron at the point of saturation and increased resistance will be considered from a similar point of view as an overloaded wire at the point of saturation and fusion. Now that the question has actually become one of practical measurement, it would be well for such important points to have definite attention given to them.

IN COURT.

The action Berry *v.* Challis at the Westminster County Court is instructive. Many points would bear commenting upon, but there is one which deserves special attention. The plaintiff claimed that work and materials were of the very best description, and about this there seemed to be some dispute; but failure did take place and was attributed to the dampness of a cellar. He naturally contended that "wet or damp was a deadly enemy to electricity." We have long argued that the probable users of electricity know as much about its performances as the suppliers do of the North Pole—that is, nothing. Suppliers might be supposed to know something of the matter, and ought to advise their clients. In this case it was known, or it should have been known, to the supplier of the apparatus, that dampness in the cellar was one of the troubles he had to provide against, and it ought to have been provided for. The world now must believe there is another "bug" the electricians cannot overcome, in the shape of a damp cellar. This conclusion is, of course, absurd. Wet and damp may be troublesome and cost something to provide against, but to argue that a lamp must go out if the switch is in a damp cellar is to own that electric lighting is impracticable, for we cannot ensure dry cellars or dry anything in this climate. It is a great pity that electrical engineers should make claims and defend their claims on such grounds as these. "Extra work" is a fair excuse for a claim, a "damp cellar" shows lamentable weakness somewhere.

ELMORE'S COPPER DEPOSITING WORKS.

On the invitation of Elmore's Patent Copper Depositing Company, a number of pressmen paid a visit to Leeds on Tuesday to see the Elmore process in operation. The party were conveyed from St. Pancras in Pullman cars attached to the 9 a.m. train, reached Leeds at 1.30, drove to the works, inspected them, and left Leeds again by the 5.30 train, reaching town shortly after 10 p.m., by no means a bad day's work. It is needless to add that the requirements of the inner man were not forgotten on the journey. The programme was carried out from first to last without a hitch, thanks to the organising powers of Messrs. F. L. and Stepney Rawson and Mr. Shurmer, secretary to the company, who accompanied the party throughout.

The depositing works are situated at Haigh Park, Hunslet, a large piece of land about 250 acres in extent, which has, we understand, been acquired by a syndicate whose members are interested in Elmore's Depositing and Elmore's Wire Companies, the latter holding leases of the ground on which their respective works stand. The Midland Railway Company's system adjoins the park, and they have undertaken to build a station on condition that workmen's houses are erected—and there is room for a small town.

At the depositing works the party were met by Mr. Saunders, manager, and the Messrs. Frank and Stanley Elmore, the latter of whom, with the Messrs. Rawson, explained the Elmore process of deposition very fully. On the way to the

MELTING SHED

a heap of rough Chili bars was pointed out, containing about 150 tons of copper. The percentage of pure metal was said to be 97, the impurities present being gold, silver, etc., which are recovered in the tanks. The melting furnace will hold four tons at a charge, but is not at present worked to its full capacity. The copper is drawn off in a molten state into a large ladle fitted on a trolley, which, when full, is run along a short tramway to a shallow well of water. The slag having been poured and raked off the top, the ladle is tipped, and the metal allowed to run very gradually into the water, where it assumes a granulated shape, known as "shot copper." It is afterwards ladled out and stacked for use in the tanks. The slag is said to contain about 12 per cent. of copper, and we understand that when the works are more fully engaged than at present, this slag will be remelted to extract this percentage. It is now allowed to accumulate for future use.

THE BOILER-HOUSE,

which was next visited, contains two double-flued Lancashire boilers by Heaton, 30ft. long by 7ft. 6in. diameter, capable of working up to about 250 h.p. Only one of these is in work at present, and that is not by any means fully loaded. The house is within easy reach of a canal running past the works, so close, indeed, that, as Mr. F. L. Rawson remarked, it will be easy with a jib crane to unload coal from boats straight into the boiler-house. Adjoining this is the

GENERATING-ROOM.

which is light and airy, and contains three Willans and Robinson engines, and three Manchester dynamos by Mather and Platt. Another engine, by Fowler, is being erected, and there is an Elwell-Parker dynamo, which is not now in use. The whole plant, we were told, would, with 240 tanks at work, turn out 25 tons of deposited copper per week. The Manchester dynamos give 750 amperes and 50 volts at 450 revolutions. One of the Willans engines and Manchester machines had been run continuously for seven months without a breakdown. Copper rods, about $1\frac{1}{16}$in. diameter, convey the current from the machines to the tanks, and a switchboard is provided by which the dynamos can be coupled up in parallel or otherwise as required.

THE TANK SHEDS

adjoin the generating-room. We were first shown a new building, which, it is hoped, will be ready for work in a few weeks' time, but which is at present waiting for its tanks. This will be capable of turning out 10 tons of copper tubes per week. The tank shed at present in work is a well-lighted and ventilated building 200ft. by 40ft., and contains 60 tanks, the majority of which were depositing on Tuesday. The current is led into the bottom of the tank, which is packed with shot copper, forming the anode, and out again by wire brushes pressing on the revolving mandrels, which form the cathode—that is, the deposition is upwards. We understand that, as a rule, plates are introduced on either side of the mandrels, and that the function of the shot copper is to reduce the tendency to the formation of sulphate, which after a time practically insulates a portion of the plates and retards the deposition. We saw these plates in the building, but in the majority of the tanks they were absent. The tanks are 12ft. by 20in. by 3ft. 6in.

The feature of the Elmore process is the deposition of the copper on continuously-revolving mandrels, and the burnishing of the metal during the process. The tanks contain mandrels of varying sizes according to the size of the tube to be produced. We will begin with the one we saw first, in which were three mandrels of 4in. diameter. These are cast-iron cylinders, mounted on wooden spindles hydraulically driven in, and having their ends insulated. A continuous line of shafting, ranging the whole length of the tanks, drives the first of these mandrels, the other two being connected by chain gearing with this one. They are so placed in the tank as to be well covered by the solution, and yet not so deep but that their surface can be seen whilst the coating is going on. The burnishers, which are of agate and cover ½in. in width, are given a to-and-fro motion on the mandrels, and we were told that one would take about 20 minutes to get from one end of the tank to the other—that is, a given spot on the mandrel would be

40 minutes before the burnisher returned to it. The Messrs. Elmore stated that this had been found in practice to be a good speed. The largest mandrel is 4ft. diameter by 15ft. 6in. long. The copper tubes deposited on this are used for glycerine making, are ⅝in. thick, and must stand a pressure of 220lb.

The tanks are connected in series, and out of the 60 in the building about 42 or 44 are usually at work at one time. The current employed is 750 amperes, and the drop in voltage averages about ·9 volt; in the 3ft. 6in. tanks it is ·86. Gutters run the whole length of the building, into which the tanks can be drained. As a rule the tank temperature is maintained at about 3deg. above that of the shed, which latter is not allowed to fall below 54deg. Steam heating pipes are provided throughout. The ordinary rate of deposition is ⅛in. per week of 168 hours, and the maximum that has been done is $\frac{5}{16}$in. per week. The density of the solution in the tanks is about 16½deg. Beaumé.

The best week's output was seven tons, and the average is five tons.

Perhaps as interesting a part of the process as any is the operation of removing the tubes from the mandrels, which is carried out in

THE MACHINE SHOP,

which is under the same roof as the depositing-shed. The mandrel is held between three rollers in such a position as to rest on the two bottom ones, while the top exerts a pressure of from 8cwt. to 12cwt. These rollers are moved gradually along the mandrel until the whole of the copper tube deposited on it has been so treated, the effect being to expand the copper sufficiently to allow of the tube being readily drawn off the mandrel. In this shop were specimens of finished tubes from 4in. to 18in. diameter, the latter being intended for papermaking.

In this department the mandrels are fitted with spindles and receive their first film of copper. The latter operation is carried out in a bath, containing an alkaline solution, at a temperature of about 90deg. to 100deg., which reduces the E.M.F. necessary. The machinery in this shop is driven by two Fowler engines, the one working the depositing tank having been running for six months without once requiring to be stopped for repairs. Here, too, is an Elwell-Parker dynamo, which supplies the lighting current for the works.

A building, at present unfinished, adjoining the machine shop, is intended for tanks up to 60ft. long, in which propeller shafts and hydraulic rams can be coppered.

TESTING A TUBE.

We now returned to the office, where it was proposed to carry out a test to show the extreme ductility and tenacity of the Elmore tubes. The test was carried out on a piece cut from a tube that had been supplied to a customer, and labelled 170, SP9. We may here remark that pieces are cut from all the tubes when made, both tube and piece marked, the latter tested, and the results entered in a book, so that a complete record is kept.

Mr. Perry F. Nursey and Mr. Stoker (Easton and Anderson) were deputed to see that the test was fairly carried out. The machine used was one by James Heriot, and had been employed on the Forth Bridge works prior to its purchase by the Elmore Company. Whilst the test was in progress, Mr. Stepney Rawson gave some illustrations of the great ductility and tenacity of Elmore copper from his experience in the French works. The result of the test gave the tensile strain withstood before breaking as 20·9 tons per square inch, and the elongation as 21 per cent. in 10in. It was stated as a basis for comparison that with a drawn tube the figures were about 15 tons and 4 per cent. respectively. Subsequently, attention was called to a case of specimen test pieces which had been subjected to the most rigid proofs of tenacity and ductility.

THE WIRE WORKS

now being erected by the Elmore Wire Company are as yet far from completion, only the walls and the iron pillars for the roof being in position. They are close to the depositing works and occupy an area of nine acres. When finished they will certainly be among the largest of their class—they will, so we are told, be capable of turning out 100 tons of stuff per week. The company will not make the wire themselves, but will cut tubes up spirally into ribbons and sell these to the drawers to draw down to any required diameter. We understood that these spirals have been cut out to a diameter as low as one millimetre.

It will be noticed that we have confined ourselves to a record of what we saw and heard on Tuesday. No figures were supplied which would throw light on what the Elmore process actually costs per pound of copper deposited; and, as a matter of fact, the works have scarcely even now settled down to commercial work. We have preferred, therefore, to refrain from criticising, or from making public the criticisms which were occasionally heard during our visit. We can say, however, that the test mentioned above showed the copper to be of extremely high tenacity, and the fracture exhibited a fibrous condition quite in accord with the claims of Mr. Elmore, though, at the same time, we are bound to say that at present it is impossible to reconcile the estimates given in published reports with the actual cost of the system. The latter seems, according to present knowledge, to greatly exceed the estimates.

We have only to add that Mr. Elmore was unable to be present owing to engagements abroad, and that his sons, Messrs. Stanley and Frank Elmore, are as enthusiastic in regard to the process as their father, have any amount of energy, and no mean capacity of brain. For the rest, to be able to journey to Leeds, spend four or five hours in going over works, and be back in town the same night, seems to us a good illustration of nineteenth century progress.

CORRESPONDENCE.

EXPLANATION WANTED.

To the Editor of the Electrical Engineer.

Sir,—We have for some years been running two dynamos from the same shafting, one giving an E.M.F. of 50 volts, the other 90 volts, and each supplying its own circuit of lamps, all in order, until a few days ago, when, after having the machines cleaned, etc., we found on commencing to run that the 90-volt dynamo would only give a voltage of 50, the same as the smaller machine, engine speed, etc., the same as usual, but when run separately each dynamo gave off the usual E.M.F.

After trying various means to get the right voltage from the larger dynamo without success, an accidental change of position of the brushes on the 50-volt dynamo brought up the voltage of the other, and they ran all right as usual. It is a new feature to me, after nearly 10 years' experience of electric lighting, and I would be glad to know the cause, if any reader will kindly explain.—Yours, etc.,

January 26, 1891. T. R. D.

THE MEYLAN-RECHNIEWSKI ELECTRIC ENERGY METER.*

BY E. MEYLAN.

Everyone engaged in the supply of electric light from central stations knows that these enterprises are seldom very remunerative for the supplier in the present state of things, and this more particularly in the large towns where the conditions of establishment of the system of distribution are very onerous. That this industry may be carried on under the normal economic conditions, the method of supply must be safeguarded by all possible guarantees. The first of these consists in guarding against the squandering of the current in the customers' houses; therefore, contracts at fixed amounts per annum should be reserved for public lighting, where the control is easy. If, as we have seen in several cases, the companies return to this system after having tried electric meters, it must be because these meters do not yet give sufficient security.

A meter may fail in two ways: inaccuracy of indication, and insecurity of working. Under the latter heading are placed stoppages, and miss fires in starting—that is, the case in which the meter does not begin to work at the moment of connection to the circuit, or when the current is turned on to the circuit.

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* Translated from *L'Electricien*.

Generally, it is the first point to which most attention is paid; inventors always insist upon the marvellous exactitude of their apparatus, and when a professor or the officials of a laboratory test a meter it is equally upon this point that their attention is naturally directed.

From the point of view of the chief engineer of a central station the case is entirely different; it is of small importance whether the meters register to within 5 per cent., if out of every 10 meters there is one which from time to time does not start, or which stops entirely. It is needless to insist more strongly upon this point, all practical men will acknowledge it at once.

It is from the standpoint of this thoroughly-appreciated idea—namely, that beyond all else it is necessary to obtain security in working—that we have, in conjunction with our collaborator M. Rechniewski, constructed the meter of which we now intend to give some description.

As is known to all interested in the subject, electric meters may be divided into two great classes, the continuous integrators and the discontinuous integrators, or the automatic reading instruments.

The first are represented at present by the chemical meters, and by what are sometimes termed motor-meters; they are characterised by the fact that the instrument gives at each instant the quantity sought, that is, $\int I\,d\,t$, or $\int E\,I\,d\,t$, according to the case, and this either by the accumulation of a metallic deposit, or by the fact that the speed of a movable part is at each instant proportional to the electric energy or to the current. The meters of the second class play the part of an operator, taking off at certain equal intervals the figures of the electric energy or the output, the instrument automatically carrying out the summing up of these variable quantities.

The meter constructed by us is of this latter class.

Let us consider the various organs which enter into the composition of a discontinuous reading meter, and the conditions they ought to satisfy. The three essential parts are: the galvanometer or measuring apparatus, the motive part, and the registering arrangement. That which first of all requires attention is the measuring instrument, and here it is necessary to enquire what it is that is best to measure. On this point we are entirely in agreement with the opinion of M. Hospitalier. The central station supplies electric energy; it is, therefore, the watts that must be measured. On the other hand, every wattmeter becomes of itself a coulomb-meter when the potential is maintained constant, so that this kind of apparatus does not present any further interest, except in the laboratory, for the study of batteries and accumulators, or for the control of batteries of accumulators in central stations. But, in these two cases, the absolute automaticity is superfluous, and the measuring instruments called registering are more appropriate.

Amongst the wattmeters may be distinguished instruments with free swing, and those in which the current only produces a pressure or a couple balanced by an opposing force, and of which the estimation must be made by the putting in action of a force or a couple equal and of opposite direction.

It is this latter type of galvanometer which we prefer for the following reasons:

1. The inertia of the pieces do not come into play; in other words, periodicity is assured.
2. The proportionality is much easier to be obtained.
3. The electro-dynamic or electro-magnetic pulls or couples may be much greater; as there is no appreciable displacement of the moving part, it can be placed in the conditions of maximum effect.

Whatever be the measuring instrument, the accuracy will be, other things being equal, so much the greater as the pulls are greater, and judged from this point of view, the electromagnetic actions are incontestably preferable to the electro-dynamic actions; nevertheless the condition of proportionality and the consideration of alternate currents has led us to make use in our wattmeters of a pressure electro-dynamometer in which we have sought to obtain the maximum pulls.

The arrangement best realising these conditions has long been pointed out by Maxwell; it has since been applied by Sir William Thomson in his last series of measuring instruments. It consists in utilising the pull of two fixed coils upon a flat coil placed parallel and as near as possible to the two first.

The readings of an electro-dynamometer of this type may be made by two different methods: by the action of a movable weight, as is done by M. Marès, or by the torsion or tension of the spring.

A movable mass has its weight invariable, but a counterweight is too sensitive to shocks and trepidations. A spring has the defect of varying with time and with the temperature. But, on the other hand, it is much easier to stretch or twist a spring in a continuous manner than to shift a weight and to push it backward.

If, therefore, on the score of accuracy, the advantages are seen practically to balance each other, on the score of simplicity of the auxiliary mechanism the spring is considerably the better. In fact, the to-and-fro movement which must be given to the movable counterpoise of a Thomson's balance can only be obtained by means of complicated mechanism with alternating movements, where the actions interfere with each other in an awkward manner On the other hand, we have been able to devise an arrangement of readings by the torsion of a spring, the raising of the arm of the balance, and the escapement of cams, in which the whole has a movement always in one direction, so that it is perfectly easy to connect it to the motor shaft.

This leads us to speak of the most important part of the automatic reading meters, the motor, which usually is called upon to furnish, by the constancy of its speed, the equal intervals of time which separate the readings, or rather the equal intervals of time during which the readings take place. In all the meters with which we are acquainted this is done by a clockwork movement wound up by an electric device furnished with a regulator, or by an isochronous motor for discontinuous currents. Now, these arrangements present two distinct disadvantages: the first, the most apparent, is that which results from the electric contacts and the sparking; in spite of all precautions these contacts gradually become dirty and cease to act; moreover, the motive force being essentially intermittent it is necessary to be absolutely certain that it will act in the position last taken by the moving part each time it returns to a state of rest. The second difficulty is the regulation of this motor: none of the simple regulators employed in clockmaking are efficacious, except within very narrow limits, and it is therefore necessary to make the motor act upon the contacts in order to make the number and the duration of the electric impulses vary equal with the variations of the mechanical resistance of the apparatus. Hence new and numerous causes of accident.

(To be continued.)

UNDERGROUND MAINS.—III.

THE CALLENDER-WEBBER SYSTEM.

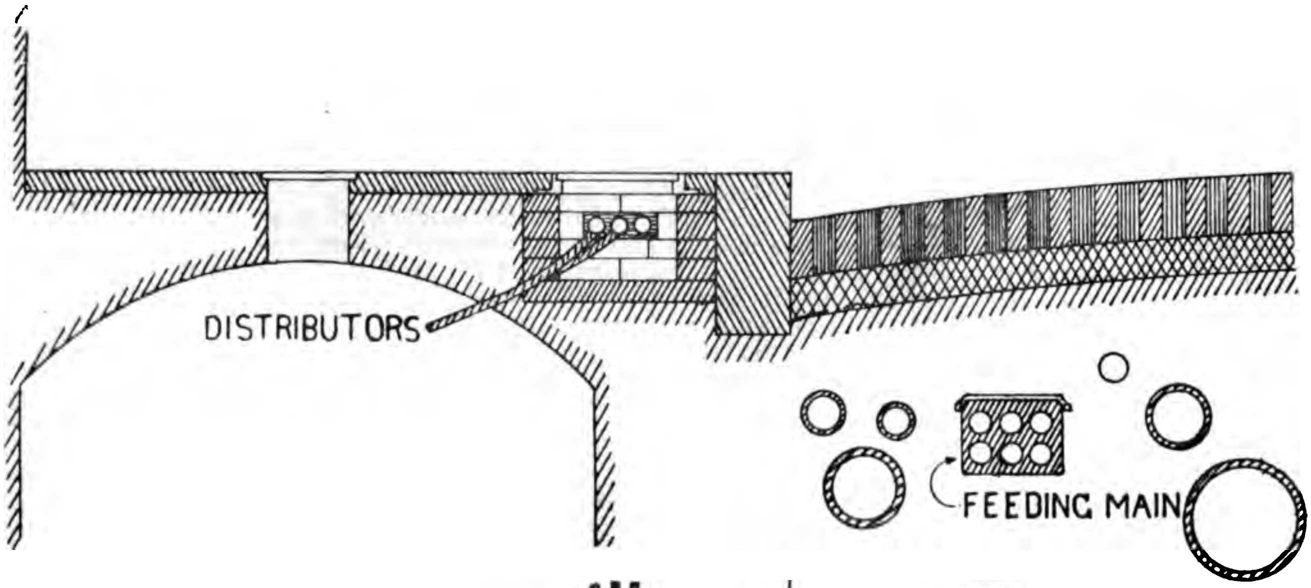
Two systems of underground mains for electric light distribution are carried out by Callender's Bitumen Telegraph and Waterproof Company, Limited, of Leadenhall-street, London. These two systems are known respectively as the Callender-Webber system and the Callender Solid system. In both of these, highly-insulated copper cables are used, laid underground in trenches and protected by bitumen. The method of using the bitumen constitutes the difference between the systems.

In the Callender-Webber system the bitumen is moulded into solid casings having holes throughout the length, and through these the insulated cables are drawn in. This gives facilities for the removal of cables and the substitution, if necessary, of others; and for the provision of spare space to be occupied by other cables as the demand increases, without the necessity for again taking up the streets.

In the Callender Solid system the insulated cables are laid in an iron trough and the whole filled in solid with melted bitumen, the cables being held practically immovable when once laid.

The decision as to which of these two systems is the most suitable depends largely upon conditions of cost and of locality. The solid system will in most cases be the cheaper, if the cable is for a certain stipulated transmission of current which will never be exceeded, or if the demand for current is known or can be estimated closely, so that necessity for alteration or addition is not likely to occur.

FIG. 1.—Callender-Webber System, Descriptive Section of Roadway with Electric Mains amongst Gas and Water Pipes.



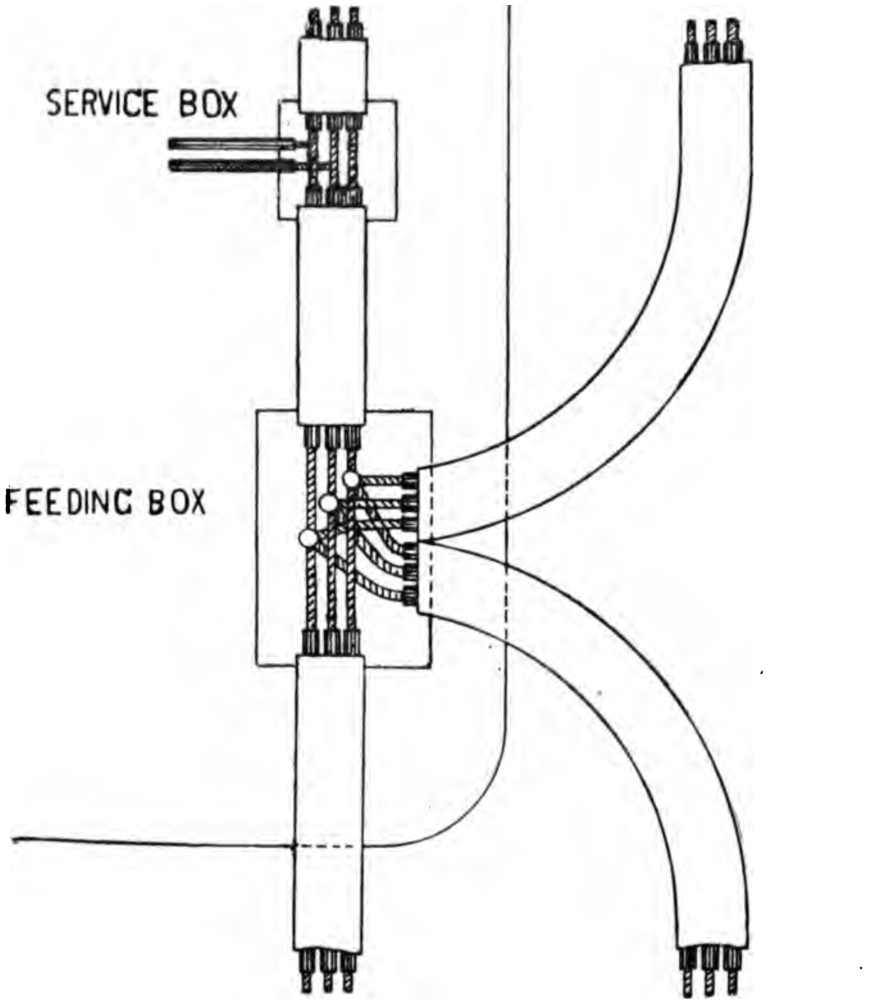


FIG. 2.—Descriptive Plan showing Feeders and Distributing Mains with Service and Feeder Box.

The Callender-Webber system is most suitable for central station work with feeders where the addition of other mains as the demand increases will be certain to be required.

Many large contracts on one or other of these plans have been carried out in all parts of the kingdom, both for central station distribution or for feeders at isolated installations, and also in combination with the various systems of copper mains for use in special situations. The numerous practical details, which are so necessary for the success of any system of distribution, have thus been worked out as the result of actual experience, and the precautions fully learnt which must be taken to ensure high insulation and safe and uninterrupted supply, as well as to assure ease in laying and in the connection of branch or house mains.

We will first describe the Callender-Webber system of underground electric mains, this being the system most applicable to networks of new central stations likely to increase in size. The system is the outcome of the joint inventions of the Callender Company and Major-General Webber, R.E., and its essential distinction lies in providing a solid yet insulating protection to the cables, and a separate way or passage for each cable run.

The general arrangement is well shown in the descriptive section and plan, Figs. 1 and 2, of the roadway, showing six feeding mains, laid under the street among a bewildering array (not at all uncommon in towns) of gas and water pipes and main sewers; with a distributing main on the three-wire system laid under the footpath—feeder boxes and service boxes being constructed flush with the pavement.

Under paved footpaths the depths at which the mains are run need only be sufficient to be just below the higher gas and water service pipes, the concrete foundation of asphalte, or the flagstones of the pavement. In practice, the bottom of the trench is usually 12in. to 18in. below the pavement level, but in cases where space is limited the casings can be run with perfect safety in 3in. or 4in. of depth. This adaptability of the system for limited space, combined with its high mechanical and electrical protection and its power of curving up, or down, or to one side, make it extremely convenient in many places where more rigid systems would be inapplicable.

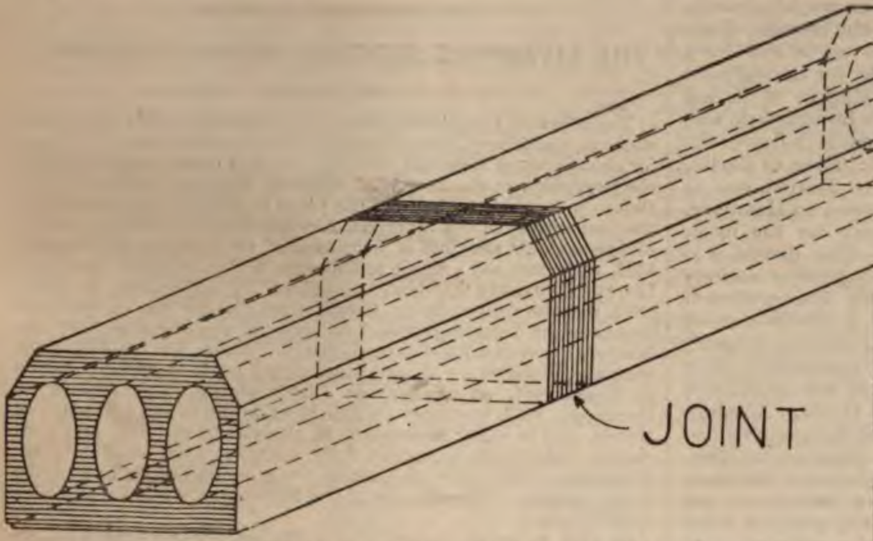


Fig. 3.—Callender-Webber Bitumen Casing showing Joint.

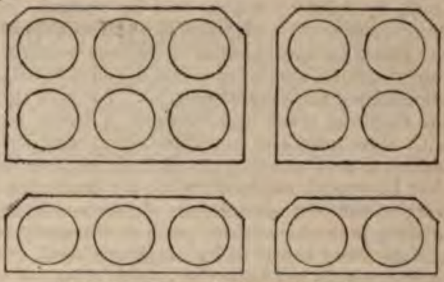


Fig. 4.—General Form of Casing.

The appearance of the bitumen casing is clearly indicated in Fig. 3. It is made in 6ft. lengths of blocks of bitumen concrete, pierced in the manufacture by a varying number of holes or ways. The standard sizes of these cable cases are shown in Fig. 4, and are for two, three, four, or six ways, of either 1½in., 1⅞in., 2⅜in., or 3in. diameter.

The bitumen concrete is composed of natural bitumen (one of the most durable materials known) mixed with sand, and wood fibre, specially treated. The resulting material is tough and strong, with great power of resistance to crushing, breaking, and tensile strains. It is impervious to water, is not affected by gas or acids found in the ground, and is a non-conductor of electricity. It does not expand or contract; and is capable of withstanding, when embedded in the ground, the weights of heavy traffic. It can be made to any shape, and the cases can be bent up or down, or to curve to the right or left on the job in the work of laying, and the process of laying is comparatively simple. When laid each way is a closed passage, completely separated from all the other ways and from earth by a insulating wall of bitumen, and the cables are, therefore, subject to no unfavourable conditions from contact with each other or from deleterious or conducting substances.

When constructing the conduit it is easy to lay the casing with a larger number of holes than is necessary for present requirements, the additional cables being easily drawn in as the demand on the network increases without opening the roadways or disturbing the traffic.

The following table gives the stock sizes, with the size of cable taken.

Sizes of Callender-Webber Casings.

Size.	1½in. ways, taking up to $^{19}/_{14}$ cable.	1⅞in. ways, taking up to $^{19}/_{11}$ or $^{37}/_{14}$.	2⅜in. ways, taking up to $^{61}/_{12}$ cable.	3in. ways, takes over ½in. sect. area, insulated.
2 way	4½in. by 2¾in.	3¼in. by 6in.	4in. by 6¾in.	5in. by 9in.
3 way	6¾in. „ 2¾in.	3¼in. „ 8½in.	4in. „ 9½in.	5in. „ 13in.
4 way	4½in. „ 4½in.	6in. „ 6in.	6¾in. „ 6¾in.	9in. „ 9in.
6 way	4¾in. „ 6¾in.	6in. „ 9in.	7in. „ 9½ir.	9in. „ 13in.

In laying mains underground, whatever the system, it is advisable to carry them as near to the houses as the cellars will admit, and as far as possible the trenches are made under the footpath. When the pavement is of a costly nature and the roadway is of macadam, it is better to run the trenches along the road, but usually the pathway, if not already occupied by telegraph mains or large cellars, is best and cheapest.

In the roadway it is customary to have the trench 3ft. deep. Under an ordinary macadamised road this depth will be quite safe for all ordinary traffic and for temperate climates. If the roadway is concreted as for wood or asphalte paving, it is sufficient to have the mains laid immediately below the level of the concrete.

(*To be continued.*)

TELEGRAPHIC COMMUNICATION BETWEEN ENGLAND AND GERMANY.

The following is a summary of the various changes and improvements in the telegraphic communication between England and Germany which have resulted from the acquisition of the Anglo-Continental cables by the Governments concerned.

For years complaints had been made of delay and irregularity in the arrival of telegrams, especially from Germany, and in the year 1886 Mr. H. C. Fischer, controller of postal telegraphs at St. Martin's-le-Grand, to whose initiative and energy most of the improvements effected are due, was deputed by the Postmaster-General to make a personal enquiry into the working arrangements of the late Submarine Company. He found an almost entire absence of system both in the management and the circulation of the traffic, and an insufficiency of direct lines of communication between England and the principal towns in Germany, especially to Berlin. The result of this paucity of direct wires was that the bulk of the traffic had to be sent by indirect routes, which often led to later telegrams reaching the addressees before others that had been handed in some time previously. There were only 10 wires nominally working direct to the several German towns—namely, two to Berlin, two to Hamburg, one to Frankfort, one to Cologne, one to Bremen, and three to Emden. The communication with Berlin, Hamburg, and Frankfort was wholly inadequate, and only something like 40 per cent. of the traffic could be sent direct, the remainder having to be transmitted by Amsterdam, Brussels and Emden. In the result, although 10 wires were nominally regarded as direct, when Brussels and Amsterdam found that they had more transmitted work on hand than could be disposed of over their own wires, they habitually cut some of the quasi-direct wires passing through their offices and used them to clear off the accumulated traffic for the German offices concerned, and this tended to throw matters in London into further confusion.

There was an entire want of system on the part of the officials of the late Submarine Telegraph Company in regard to the selection of the traffic for indirect despatch, and all that seemed to be done was to get rid of it by forwarding it indiscriminately to one or other of the three transmitting offices mentioned. The effect of this irregular circulation of the traffic was that there was great inequality in the transit times. It was found that three cable conductors were kept "spare" and were not used at all, unless other wires were interrupted—namely, two to Belgium and one to Holland.

Thanks to the cordial co-operation of the German Administration, arrangements were made in advance of the transfer of the cables for working a larger number of direct wires, and for a proper and systematic circulation of the traffic for the different parts of Germany to the offices best able to dispose of it, and from the very first these circulation lists were brought into use. The available cable wires were then allotted as follows, the spare wires being brought into constant use: Four to Berlin, three to Hamburg, two at Frankfort, two to Emden, one to Bremen, one to Cologne, and one from Liverpool to Hamburg. Thus the number of direct wires to Germany for the international traffic was increased from 10 to 14. The diversion of traffic by indirect routes was by mutual arrangement entirely done away with, and when in times of partial interruption of the direct communication it became needful to divert some of the telegrams, special care was taken that the traffic was properly selected for the several places. To meet the representations of the shipping trade at Liverpool, a direct wire was established with Hamburg, and in collaboration with the German Administration a very carefully-studied circulation list was prepared, so that Liverpool might circulate its traffic for Germany to Hamburg to the best advantage. Liverpool then became the transmitting point for various parts of Germany for Manchester and certain other towns in its neighbourhood. The result of these arrangements has been the entire cessation of complaints as to messages having been sent out of their proper order, while complaints of delay have likewise almost ceased.

In order to add to the speed of working the wires in the Norderney cable, repeaters were established at Lowestoft with highly satisfactory results. This has been largely due to the very able manner in which Emden has co-operated in the matter. The directors of the Hamburg office took a special interest in improving the carrying capacity of the faulty wire in the Norderney cable, which, under the Submarine Company, had only given very poor results, some 150, or at most 200, telegrams a day being dealt with. By mutual arrangement picked clerks were appointed to the wire at both ends, with the result that the wire, faulty as it is, now carries more than 400 messages a day. The Bremen wire has of late been worked by the Hughes system, and this has increased its carrying capacity by about 80 per cent., much to the advantage of the service. In concert with the German authorities, the daily hours of working the more important circuits have been extended, so as to provide better for the earlier and later flow of the traffic; and it has also been arranged to remain in direct communication with Frankfort and Cologne throughout the night and on Sundays, instead of leaving the traffic to be transmitted by Brussels, as was formerly done, leading to frequent complaints of delay to Press messages.

A more perfect system of testing the various wires has been mutually concerted between the authorities here and in Germany. The battery power has also been augmented where this was found to be needed, and every effort has been made to put the whole of the apparatus in better working order, with marked results. One very gratifying feature throughout has been the ready and willing co-operation that has been shown at all points in Germany in anything tending to improve the service between the two countries, and it is no doubt to this that much of the present satisfactory state of things is due.

It would perhaps be superfluous to mention in detail all the measures that have been arranged locally in London for the better transaction of the business, for the comfort of the staff, and also for the introduction of a better state of discipline; but much has been done in this direction. For example, under the Submarine Company's *régime* the telegraphists were expected to get their dinners while at work, without relief; but now a dining-room has been provided, and dinner relief afforded, so that there is no break in the continuity of the working as used to be the case, and that, too, during the busier hours of the day. It was the intention of the department to remove the working of the cable wires from the first to the central office at the General Post Office, but owing to the magnitude of the work involved in the transfer and the want of space in the building, it has been found impossible to arrange this up to the present time. Special provision, has, however, now been made for an important branch of the secretary's office to be removed elsewhere to a building which is being constructed for the purpose, and this will afford the necessary space for transferring the cable working to the central office. When this is effected no doubt further improvements in the service will be brought about, as the cable instruments and the instruments communicating with all parts of the United Kingdom will then be under the same roof, and as the tube transit will be done away with and the handlings reduced, it may confidently be expected that the traffic as a whole will materially benefit.

The improved communication, added to the reduction in the tariff, has led to a considerable increase in the number of telegrams, so much so that all the wires are now well filled, and there is no margin whatever for further increase, and in fact any disturbance of the communication at once gives rise to delay.—*Times.*

THE LIVERPOOL ELECTRIC SUPPLY STATIONS.*

BY A. BROMLEY HOLMES, M.I.C.E.

The object of the present paper is to describe briefly the central stations, machinery, and appliances now in operation in Liverpool for the supply of electricity for lighting and other purposes under the provisions of the Liverpool Electric Lighting Order of 1889. Before proceeding to describe the plant in detail a few words as to the past history of the Liverpool Electric Supply Company may be of interest. At the date of formation of the company in January, 1883, there was not a single installation of incandescent lamps in Liverpool, and the first building lighted by this means, in July, 1883, was the restaurant in Eberle-street, where the current was generated by a gas engine and dynamo on the premises, and the light supplied at a fixed annual charge. About the same date the company acquired a site, and constructed its first central station in Rose-street, off Lime-street. This station was started in December, 1883, to supply electric light to the Grand and Adelphi Hotels, and to other consumers in the neighbourhood, and continued without intermission in daily operation from that date till November, 1890, when the mains were connected to one of the newer stations. The capacity of the Rose-street station was under 1,000 lamps.

In 1887 a larger station was built, and commenced work in December of that year in Tithebarn-street. This now forms part of the Highfield-street station. In September, 1888, the Harrington-street station was completed and at work. In 1889 the company's new works, offices, and central station were built in Highfield-street, and the supply of electricity began in October of that year. The company's latest station in Oldham-place commenced work in October, 1890.

The following figures show the rapid extension of electric lighting in Liverpool, the number of lamps of 16 c.p. (or their equivalent) connected with the company's stations being as follows:

On January 1st,	1888	977	16-c.p. lamps.
,,	1889	3,330	,,
,,	1890	6,711	,,
,,	1891	11,750	,,

In the earlier stations separate engines and belt-driven dynamos were used, but these have from time to time been replaced, and the plant is now all of one uniform pattern, each engine and dynamo being combined on one bed-plate. The capacity of the three stations now at work is as follows:

Highfield-street	7,000	lamps, capable of extension to	13,000
Harrington-street ...	4,000	,, ,, ,,	4,000
Oldham-place	4,500	,, ,, ,,	20,000
Total	15,500	Total	37,000

The above figures give the number of 16-c.p. lamps that the machinery is actually capable of supplying direct at one time; and as experience has shown that never more than 75 per cent. of the lamps connected to the supply mains are in use at any one hour, the above plant would have a working margin of 25 per cent. spare power for the number of lamps stated, without taking into account the storage of electricity always available from the accumulators.

The system in use is a direct-current continuous supply at a pressure of 110 volts, all the mains being in simple parallel. It may be convenient to give a detailed description of the plant before describing the method of working.

The boilers are 28ft. long and 7ft. 6in. in diameter, and are made of mild steel. The shell-plates and end-plates are ⅝in. thick, and the ends are strengthened by gusset-stays. The boilers have two flues, 3ft. diameter, tapered to 2ft. 6in. diameter at the back end, and made of mild steel plates $\frac{7}{16}$in. thick, and each flue is fitted with six steel Galloway tubes. The working pressure is from 110lb. to 120lb. per square inch. Of the 10 boilers in use, seven are fitted with Proctor's mechanical stoker, and the remaining three with Viccars's mechanical stoker.

The water supply is taken into the storage tanks from the town mains, and, where practicable, a duplicate service has been carried into the station from a second main. Two feed pumps (or a feed pump and injectors) are provided at each station, and a complete double system of feed pipes, with separate check valves, on each boiler. Feed-water heaters are used, and an arrangement of valves, by which, in case of any breakdown of a heater, the water can be sent direct to the boiler or pumps without passing through the heater. The steam and exhaust pipes are divided into sections, so that any necessary repairs may be effected without stopping the station.

The engines are Willans central-valve compound engines of two sizes, 10 of them being of the I.I. size, with cylinders 14in. and

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* Paper read at the meeting of the Liverpool Engineering Society, January 21, 1891.

20in. diameter and 9in. stroke, capable of indicating 180 h.p., the remaining three engines being of the G.G. size, with cylinders 10in. and 14in. diameter and 6in. stroke, indicating 60 h.p. All the engines, which are single acting, have two cranks placed on opposite sides of the crankshaft. Each line of pistons is connected to its corresponding crank by a pair of connecting rods, between which work the eccentric and eccentric rod which actuate the valve gear. The eccentric is forged solid on the crank-pin. Piston valves are used, working inside the hollow piston rod which connects the pistons. All the moving parts are in constant compression and subject to a downward thrust.

At the top of the engine is the steam-chest, common to both lines of cylinders. Underneath the steam-chest are the high-pressure cylinders; next, the low-pressure cylinders, and underneath these latter the guide cylinders, which act as air-cushions. A sight-feed lubricator is provided on the steam-chest, and a grease-cup on the top of each line of cylinders for giving a flush of oil if needed. The chamber in which the cranks work is filled with water up to the level of crankshaft. A small proportion of castor-oil is added to the water, and is churned up with it by the movement of the cranks, and effectually lubricates the internal bearings. The governor is fitted directly on to the end of the crankshaft, and actuates an equilibrium throttle-valve fixed at the entrance of the steam-chest. The bed-plate of engine is extended to carry the dynamo. Each engine is fitted with a cylindrical steam separator, which ensures a supply of dry steam.

The dynamos have magnets of the single-inverted horseshoe type, with massive wrought-iron limbs. The armature shafts are coupled directly on to the crankshafts of the engines. The dynamos for the smaller engines give an output of 300 amperes, and an E.M.F. of from 110 to 140 volts, at from 450 to 500 revolutions per minute. The larger dynamos give 900 amperes, and from 115 to 135 volts, at 375 revolutions per minute.

Some of the dynamos are compound wound, but the later patterns are plain shunt wound, and all have a variable resistance attached to them, by which the current through the shunt circuit can be varied and the E.M.F. regulated at will. Two of the dynamos were manufactured by Crompton and Co., and the rest by Siemens Brothers. In the Crompton dynamos the resistance of the armature is ·0028 ohm and of the shunt coils 11 ohms.

The armature is built up of charcoal iron discs keyed directly on to a steel shaft 5¾in. diameter. The core is 36in. long and 18in. diameter. The effort is transmitted from the shaft to the discs by the feather, and from the discs to the winding by means of delta metal driving teeth fixed in holes drilled in the core. The winding consists of 80 turns of pressed stranded bars, measuring ·6in. by ·63in. in section. These bars are made slightly taper, so that they may lie evenly against each other. The armature bars are connected by copper end connections, turned right and left on what is termed the butterfly plan The commutator is made of cast copper sections, and is 9½in. in diameter and 8⅝in. long.

In the Siemens dynamos the resistance of the armature is ·0024 ohm and of the magnet coils six ohms. The armature is constructed with a core of thin sheet-iron discs threaded upon a round steel shaft. The core is insulated and surrounded with 144 insulated bars, each bar consisting of a number of wires stranded together and pressed into a square shape. The insulated bars are connected to one another and to the commutator, as usual in drum armatures. The armature is bound with bands of steel wire to resist the centrifugal force generated whilst revolving.

The accumulators have lead containing boxes, each about 4ft. long by 12in. wide and 13in. deep, supported on heavy wood slabs resting on glass insulators.

The cells are of two kinds, manufactured respectively by the Electric Construction Corporation (formerly known as the Electrical Power Storage Company), and by the Crompton-Howell Electrical Storage Company. The Construction Company's cells are of the well-known L type, E.P.S. pattern, manufactured as follows: The grids are cast in iron chills, the negatives of lead-antimony alloy, and the positives of lead. Both kinds of grids are pasted with red lead mixed into a paste with dilute sulphuric acid, and are then dried and put into the forming tanks. Charging is commenced with a current density of two amperes per positive plate, increasing up to four amperes, the total number of ampere-hours being about 100 each for the positive plates, which are then removed, and their places taken by blind positives, with which the completion of the forming of the negatives, which require about 200 ampere-hours per plate, is continued. When formed, the plates are taken out of the tanks and burned together in sections as required. Each central station cell has three sections of 27 plates each, or 81 plates in all, each plate measuring 9½in. by 9in. by $\frac{3}{16}$in. thick. The maximum safe rate of discharge of the cells is 250 amperes, and the storage capacity about 1,700 ampere-hours at ordinary rates of discharge.

The plates of the Crompton-Howell cells are composed of porous lead, the structure of the plates being entirely crystalline and presenting a large surface to the electrolyte. The active material is formed electrically right through the plate, and does not readily fall away, but adheres firmly to the lead. The plates are mounted on celluloid racks resting on the bottom of the cells, and are kept apart at the top by celluloid combs. The plates are not connected into sections, but the positives of one cell and the negatives of the next are burned on to a common lead bar, supported on insulators between each cell. Each cell has 51 plates 8½in. by 8½in. by ¼in. thick, and may safely be discharged at the rate of 400 amperes, having a storage capacity of 800 ampere-hours when discharged at the normal rate of, say, 200 amperes.

All the distributing mains of the Liverpool Electric Supply Company are laid underground, and have been manufactured and laid by the Callender Company. The conductors are of stranded copper wire, with a conductivity of 98 per cent. The largest feeding mains are composed of 91 No. 9 wires, and have a sectional area of 1·57 square inches. The conductor is covered with two layers of jute yarn, and boiled in refined bitumen. It is next wrapped with parchment tape and covered with a lead casing. The lead is protected by an outside covering of rough jute yarn treated with asphalte and tar. The ordinary feeders are made of 61 No. 11 wires with an area of six of a square inch, and the distributors of 37 No. 13 wires one-quarter of a square inch in area. In both these mains the copper conductor is covered by a solid sheath of bitite or vulcanised bitumen put on under heavy pressure at one operation. This core is next taped and compounded, and finally braided with hemp yarn and passed through a bath of asphalte compound.

The mains are laid in cast-iron troughs ¼in. thick and about 6ft. long, with socket joints. When the troughs are placed in position about ¼in. of refined bitumen in a molten state is run in, and, before setting, spacing bridges of wood are placed in it about 18in. apart. These bridges support the cables and hold them in place, clear of the sides and bottom of the trough and of each other. Bitumen is then run in so as to entirely cover the cables and fill up the iron troughs to within ½in. of the top. The troughs are then finished by a covering of Portland cement concrete about 1in. thick. Strong cast-iron covers are in some cases substituted for the concrete.

The service lines from the distributing mains to the consumers' premises are made of 19 No. 14 wires, insulated and covered with lead pipe, and are run in wood grooved casing, filled in with bitumen and protected with a hard-wood cover strip. The connections of the various lengths of mains to each other, and of the feeders to the distributors, are made by sweating copper lug pieces on to the ends of the cables and by bolting copper connecting bars to the lugs. The distributing mains are jointed in a similar way, the connecting bars being fitted with terminal screws for the attachment of fusible tin strips, to which the service lines are attached.

The connections described above are made in cast-iron joint boxes, measuring inside 16in. by 12in. by 12in., provided with socket pieces to receive the ends of the cast-iron troughs in which the mains are laid. Each box has a strong cast-iron cover held down by a central bronze bolt and crossbar. A watertight joint is secured by means of a soft indiarubber washer between the cover and the box. All joint-boxes are below the level of the pavement, and the surface of the footway is completed by an iron frame and surface plate, by means of which access is afforded to the joint-box. In many cases the surface plates are formed in cement to match the adjoining pavement.

The general arrangement of mains is as follows: A pair of distributing mains are laid under the footways on each side of each street, and are connected together to form a complete distributing network, to which are connected all the service lines to consumers' premises. For convenience in working the network is divided into sections. The supply of current is brought to selected distributing points in this network by heavy feeding mains, which run direct from the generating stations.

The feeding mains are so proportioned relatively to the distance from the station of each distributing point and the number of lamps to be supplied from it that the percentage of loss in pressure in each feeding main may be as nearly as possible the same; in other words, if the lamps were turned on and off uniformly all over the area of supply, a constant pressure might be maintained throughout the network by varying the E.M.F. of the dynamos at central station in exact proportion to the amount of current supplied. As a matter of practice, however, the hours of demand vary in different streets and districts, and it is found necessary not only to vary the station pressure as a whole, but also to regulate the pressure for each set of feeders individually. The following figures will give some idea of the extent of the mains already laid: The district served by the mains extends 1,300 yards (measured straight on map) from Lime-street to bottom of Brunswick-street, 1,000 yards from Old Hall-street to head post office in Canning-place, and 1,550 yards from Highfield-street to top of Bold-street and Wood-street.

The length of frontage along which distributing mains are laid is 9¼ miles. The total length of single cable used throughout the area is 41 miles. Taking a pair of cables to form a main, the lengths of the various classes of mains are as follows:

Feeding mains	10 miles.
Distributing mains	9 miles.
Service lines	1½ miles.
Total	20½ miles.

The weight of copper in the mains is 210 tons. The number of joint-boxes, service boxes, and pressure wire boxes is 630. The number of separate service lines is 275, but many of these serve for the supply of several consumers. Pressure wires are run in specially-laid cast-iron pipes from the various distributing points to the central stations, and are connected to instruments by means of which the actual pressure at each point is indicated to the engineer in charge and is continuously and automatically registered. The main switchboard in each station is fitted with an ammeter and registering pressure indicator for each pair of feeders. These street mains are connected up to massive terminals on the switchboard fitted with safety cut-out strips, which would fuse in the event of any serious short circuit on the main. All the dynamos in a station are arranged to work in parallel on to a pair of positive and negative collecting conductors, and are switched in and out of circuit as the variations in load require.

Each negative feeding main is connected from its cut-out to the station main negative conductor, and each positive feeding main is connected through an ammeter to a main regulating switch, which, when in its normal position, completes contact with the station main positive conductor. By moving the regulating switch it is possible to introduce a number of accumulators, one after another, in the circuit of any desired feeder. These accumulators are arranged in opposition to the dynamo current, and, consequently, the pressure in the feeder, is reduced by two volts for each cell put into circuit by the regulating switch. This at first sight may appear a wasteful method of regulation, but in practice the load is found to rise so uniformly over the whole area of supply that the amount of energy absorbed in regulation is practically unimportant.

The battery of accumulators at each station is capable of supplying 500 lamps at a time, thus enabling the machinery to be stopped at from 10 to 12 o'clock at night and in some cases entirely on Sunday, and also largely in the daytime in summer. The discharge from the accumulators is registered by a recording ammeter. By a special arrangement of dividing the accumulators into sections, devised by the author, they are charged from the dynamos supplying the town at the ordinary working pressure, and by a little care it is in this way possible to so regulate the load on the engines and dynamos as to run them at their highest efficiency.

The very great advantage of this will be appreciated from an inspection of the efficiency diagram of one of the 900 ampere sets of plant, from which it is seen that the electrical efficiency (that is to say, the ratio of the external electrical output of the dynamo to the i.h.p. in the cylinders) is as follows:

At	150	amperes or	1/6	load	50	per cent.
,,	300	,,	1/3	,,	65	,,
,,	600	,,	2/3	,,	79	,,
,,	900	,,	full	,,	86	,,

Continuous tests of the insulation resistance of the mains are made at each station by means of a special apparatus devised by the author for this purpose. If two lamps be connected in series between the positive and negative mains, and a point between the lamps be connected to the earth, the lamps will be found to burn with a variation in brilliancy proportional to the relative insulation resistance of the mains to which each lamp is attached. If two voltmeters be substituted for the lamps, their readings will indicate the same ratio. In the apparatus referred to, a registering voltmeter is used to indicate this ratio continuously. By a suitable arrangement of switches, an ammeter with one terminal connected to earth can be momentarily connected to either main, and the insulation resistance in ohms of the main to which the instrument is not connected is readily arrived at by dividing the station pressure in volts by the number of amperes indicated by the ammeter. For example, if the station pressure be 120 volts, and the ammeter reading three amperes, the resistance of the opposite main would be 40 ohms.

The ammeter used for testing must be accurate at low readings, and therefore is only made to read up to five amperes. In the event of any dead earth fault on the mains the instrument might be destroyed by the sudden rush of current, and to prevent such an accident a magnetic cut-out is placed in series with the ammeter. When more than five amperes passes through the cut-out it breaks contact, leaving in circuit a resistance coil of 25 ohms, so that the current through the instrument, with a station pressure of 125 volts, cannot exceed five amperes. By this contrivance it is possible to measure faults of very low resistance.

The Hookham electric meter used by the company consists of a simple electromotor doing work against the retarding influence of Foucault currents generated in a copper disc rotating between the poles of a permanent magnet. The armature coils are built up on the copper brake disc, and the axis carries a worm which actuates a train of counting gear. The meter is calibrated so that the dial reads directly in Board of Trade units. The speed of rotation (subject to a small frictional error at small loads) is proportional to the current.

Diagrams are exhibited which show the very variable demands made on central station plant at different hours of the day and at various seasons of the year. From these it will be seen that the number of Board of Trade units used per lamp per month varies from 6·3 units in January to 1·2 units in June. Also, that in December the output reaches 4,060 amperes, whilst in June it does not exceed 500 amperes.

This paper has been limited to the description of the central station plant and appliances of the Liverpool Electric Supply Company, and to the method of working simply from an engineering point of view, and no attempt has been made to deal with commercial details either of capital expenditure of working costs, which may be more usefully brought before this society, after longer experience, at a future date.

ELECTRIC LOCK AND BLOCK SIGNALLING.

On the 14th instant, as we mentioned in a recent note, Mr. Spagnoletti, M.I.C.E., read a paper before the Inventors' Institute on the "Electric Locking and Block System," as applied on the City and South London (Electric) Railway.

Mr. Spagnoletti, after a concise description of the construction of the line, fully explained and described the working of the electric locking system as applied to both double and single lines. The lever of the starting signal is always kept locked to "danger," and before a signalman can possibly pull over and lower the signal arm for a train to leave his station he must send a bell-code to the next station in advance to unlock his lever. This can only be done by the man at the station in advance sending a current of electricity by an instrument in his signal-box, and the act of sending this current locks up his instrument so that he cannot possibly send another until the train arrives at his station and passes the clearing point, when it passes over a contact-maker (a treadle fixed beneath the rail) and resets his instrument so that it can be worked again for a second train, but not until the first train has arrived and the section is clear.

When the signal arm has been unlocked and lowered for a train to proceed, after its departure it must be replaced to "danger," and it cannot be lowered a second time until the lever has been again unlocked from the station in advance, and the signalman at the station in advance cannot again unlock until the train occupying the section has cleared it and reset his instrument to enable him to do so. This piece of automatic working, which gives no signal itself, forms a thorough check upon the signalman, and prevents him making any mistake from any misapprehensions he may have in his mind. It simply resets his instrument to enable him to work it again, and checks him if he should attempt to work it at a time when he ought not to do so before the section is clear. When the starting signal lever has been lowered for a train to leave it must be put back again, or the signalman cannot take the lock off for a following train coming from the station in the rear.

In working single lines, when taking the lock off at either end from the opposite end of the single line section for a train to proceed, the act of releasing the lock at the other end locks up the instrument and severs the wire which conveys the current to the lock in either direction, so that it is impossible to take the lock off again at either end until the train occupying the section has arrived at the proper place in whichever direction it is going and resets the instrument and re-establishes the circuit. When the lock has been taken off, by the station in advance, for a train to proceed over the section, and the train from any cause should not proceed, the signalman is compelled to move his lever and lock it before he can take the lock off at the other end for a train coming in the opposite direction. Mr. Spagnoletti also pointed out that in working junctions one instrument only is required, as by means of a switch any number of line wires connecting the next stations on the various branches can be joined to this one instrument without affecting the safety of the working. In crossing trains from one road to the other he explained that when the levers affecting cross-over roads were unlocked trains could not be allowed to approach the station on either the up and down line, and *vice versâ*. He pointed out that a section might be divided into two sections and yet be worked by the same signalman, by having an intermediate signal locked from the same signal-box, so that the one signalman could work both sections, first taking off the lock at the station in the rear for a train to proceed to the intermediate signal fixed at a certain point, which signal lever can only be unlocked by himself when the second section is clear, thus saving the expense of an extra signal station and staff to work it.

On local lines where trains stop at every station there is no need for fogmen in foggy weather, because no train enters a section until it is quite clear, and the train itself controls the working of the section. Should any derangement occur to the instrument in working, the safety of the system is not affected, neither is any delay to the traffic caused because the derangement locks everything up on the side of safety, and the instrument can be worked by hand as well as by the treadle under the guidance of the inspector or other authorised person when any derangement may occur. This system does not relieve the signalman from any of his present responsibilities; it simply checks him from doing wrong if he should attempt to do so, and prevents him from working the signals when he should not do so. This system is at work on many lines and is giving every satisfaction. It is a system which will, no doubt, grow as it becomes better known and understood, and it is one which evidently will greatly add to the safety of railway working.

Diagrams and working instruments for two stations and intermediate section of line were exhibited and explained.

PHYSICAL SOCIETY.—Jan. 16, 1891.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

The thanks of the meeting were unanimously accorded to the Maxwell Memorial Committee for presenting to the society a copy of Maxwell's scientific papers.

Prof. G. M. Minchin, M.A., read a paper on "**Photo-electricity.**" His experiments on the subject were commenced in 1877 in attempting to produce a photographic image of a distant object. The result sought for has not hitherto been attained, but the experiments have led to the discovery of many interesting phenomena. Some of these were shown to the meeting. Electric currents are produced by the action of light on silver plates coated with collodion or gelatine, emulsions of bromide, chloride, iodide, and other silver salts, or with eosine, fluorescine, and other aniline dyes, when the plates are immersed in a suitable liquid, and one plate illuminated whilst the other is screened. The directions of the currents depend on the materials employed, and the blue end of the spectrum is most effective. Currents have a photographic effect on the plates, and this action is strictly confined to the parts through which the current has passed. Comparatively strong currents were obtained from plates with eosine and gelatine. A curious reversal was observed with some cells, the exposed plate first being positive to the screened one, and almost immediately afterwards became negative. On shutting off the light a transient increase of current resulted, and afterwards disappears gradually. M. Becquerel, who has studied the action of silver plates coated with bromide, etc., concludes that the nature of the exposed plate (whether positive or negative) depends on the thickness of the surface layer. The E.M.F. of such cells rarely exceeds $\frac{1}{20}$th of a volt. Uncleaned tinfoil plates in common tap water give a current when one is exposed to light and the other screened. Cleaning the plates destroys the effect. In nearly every case the exposed plate was first positive, and after a time became negative, and by exposing various parts of a plate (some portions of which had been previously exposed) the currents could be varied in direction at will. These peculiarities may explain the known divergence of tin from Volta's law. The phenomena have also been studied by aid of the electrometer. Tin foil obtained from tobacco packages was found to be very sensitive to light. One side of such foil is dull and the other bright. By pasting slips of it on opposite sides of a glass plate, so that dissimilar sides were outermost, and immersing them in alcohol, a cell giving an E.M.F. of $\frac{1}{16}$ volt, when the dull side was exposed to light, was obtained. The addition of any salt to the liquid with a view to diminishing the resistance, invariably reduced the E.M.F. Experiment showed that the alcohols were by far the best liquids to use with tin plates. A process for producing very sensitive tin plates was described, which apparently results in the formation of white oxide of tin on the surface of the foil. With one such plate and another unsensitised plate the best results have been obtained by immersing them in methyl alcohol prepared from oil of winter green. From experiments on the variation of E.M.F. with the intensity of light it was found that the square of the E.M.F. is proportional to the intensity. Some tin cells behave in a very peculiar manner, for it often happens that a good cell will exhibit no E.M.F. after being kept a few days. A slight impulse or tap given to the cell or its support restores the sensitiveness. Another impulse makes the cell unsensitive, and these effects can be repeated indefinitely. Such cells the author calls "impulsion cells," and some were exhibited at the meeting. The sensitised plate of one of these cells had different properties at its two ends, for impulses had no effect on the nature of the lower end, but changed the upper end from positive to negative and *vice versâ*. Electromagnetic impulses, such as produced by sparks, are capable of altering cells from the unsensitive to the sensitive state, but fail to produce the reverse effect; a Hertz oscillator restored the sensitive state in a cell placed at a distance of 81ft. away. The "impulsion effects" can be got rid of by renewing the alcohol on several successive days. During last year the author made some selenium cells by spreading the melted substance on metal plates, and immersing them in liquids together with an uncoated plate. Of the various metals and liquids tried, aluminium and acetone gave the best effects. The process of forming these "seleno-aluminium cells" was described. One of their peculiarities is that they are nearly equally sensitive to rays of all colours; and when exposed to strong light may give an E.M.F. of $\frac{1}{2}$ to $\frac{2}{3}$ of a volt, the sensitised plate being negative. An arrangement of 50 cells in series, with an electrometer, was exhibited, whereby the E.M.F. generated by light falling on the cells could be caused to ring a bell, light or extinguish electric lamps, etc. In conclusion, the author pointed out the possible applications of photo-electricity to photometry, tele-photography, and the utilisation of solar energy. At the request of the President, Prof. Minchin promised to show the experiments on Feb. 13, on which date the discussion on the paper is to take place.

Prof. F. R. Barrell, B.A., exhibited and described a lecture-room apparatus for determining the acceleration due to gravity. A number of iron balls are allowed to fall through a certain height in such a way that one starts off when its predecessor arrives at its destination. From the time occupied by all the balls, the time for one can be found, and, knowing the distance traversed, "g" can be determined. The apparatus consists of two electromagnets joined in series with a battery and key, together with a ball-feeding device. One of the magnets is vertically over the key and serves to catch the balls as they emerge from the feeding tube, whilst the other magnet actuates a kind of slide for supplying successive balls. When one ball falls on the key it breaks circuit, and thus causes the first mentioned to let go its ball. The key then springs up again, thus making circuit; the feeding magnet then supplies another ball, which is caught by the holding magnet until the falling ball reaches the key, and the operations are repeated. Fairly accurate results can be obtained by the apparatus.

Sir John Conroy's paper "On the Change in the Absorption Spectrum of Cobalt Glass by Heat," was postponed.

LEGAL INTELLIGENCE.

BERRY v. CHALLIS.

Claim by Electrical Engineers.

In the Westminster County Court recently, the case of Berry *v.* Challis came on for hearing before His Honour Judge Bayley. The proceedings were brought at the instance of the plaintiffs, who are a firm of electrical engineers carying on business in Gerard-street, Soho, and the claim was for £26 odd for work done and materials supplied in fixing up two arc lamps outside the defendant's premises at the corner of Coventry-street.

Mr. Cooper Wylde was counsel for the plaintiff, and Mr. Tatlock appeared on behalf of the defendant.

The defendant admitted a portion of the claim, and paid the money into court, thus reducing the amount in dispute to £7. 18s. 3d.

In opening the plaintiff's case, **Mr. Cooper Wylde** said that in May of last year the defendant communicated with the plaintiff with a view to having two electric lamps fitted up outside his premises, which were situate at the corner of Coventry-street and Rupert-street. Negotiations were entered into between the parties, and ultimately the plaintiff received definite instructions to proceed with the work. In due course the lamps were completed, and the defendant's premises were lighted by electricity. They had not, however, been up long before the defendant intimated that their position did not please him, and he must have them fixed considerably higher up. A good deal of the work which had been done had consequently to be done over again, and new supports had to be provided, thus entailing extra expense, and it was in respect of these and other items that the present dispute had arisen. The plaintiff contended that as it was no fault of theirs that the work had to be done over again, they were justified in charging it to the defendant.

The plaintiff was called, and said that he had a conversation with the defendant as to the proposed alterations, and told him that if it was to be done it must be at his expense, to which suggestion he agreed. He was quite sure that the work was properly and efficiently done by his men, and if there was any difficulty with the light it was not through any fault of his. The materials supplied for the work were of the very best description. One of the reasons why the light failed was, that the cellar from which it was turned on and off was damp, and it was a well-known fact that wet or damp was a deadly enemy to electricity.

Several other witnesses were called and gave evidence as to the manner in which the work was done.

For the defence, it was contended that the amount which had been paid into court was all the defendant was entitled to pay, as a good deal of the work which was claimed for was rendered necessary not through any fault of the defendant, but in consequence of the plaintiff's faulty workmanship.

After a long hearing, his **Honour** came to the conclusion that the money which had been paid into court was sufficient, and that being so, entered judgment for the defendant.

UNITED TELEPHONE COMPANY, LIMITED, v. ANDREW ERSKINE MUIRHEAD.

In the Edinburgh Court of Sessions on Friday, before Lord Wellwood, the United Telephone Company, Limited, and the National Telephone Company, Limited, London, sued Andrew Erskine Muirhead, merchant, Cart Forge, Crossmyloof, Glasgow, to have the defendant interdicted from infringing the letters patent, dated July, 1877, granted to Thomas Alva Edison, of Menlo Park, New Jersey, U.S.A., for the invention of "improvements in instruments for controlling by sound the transmission of electric currents, and the production of corresponding sounds at a distance," and from making, using, and exercising or vending, during the continuance of the letters patent, the invention described therein. £500 is sought in name of damages for the alleged infringement, and delivery is also sought of all instruments possessed or controlled by the pursuer, including the "Ader" transmitters, which are made in infringement of the letters patent, and also all instruments made according to the manner described in the letters patent dated December, 1876, granted to William Morgan, of Brandon and Morgan-Brown, engineers, London and Paris, for the invention of "improvements in electric telephony (transmitting or causing sounds for telegraphing messages) and telephonic apparatus," a communication from abroad by Alexander Graham Bell, of Boston University, U.S.A. The letters patent in question are vested in the United Telephone Company, subject to certain rights to the National Telephone Company. The pursuers say that the defender has been violating their letters patent by erecting telephone transmitters and receivers of the "Ader" type. The defender says that the statements of the pursuers, so far as material, are unfounded in fact, and that he ought to be assoilzied.

The record was closed, and the case sent to the Procedure Roll.

COMPANIES' MEETINGS.

ELMORE'S AUSTRO-HUNGARIAN COPPER DEPOSITING COMPANY.

The first general meeting of this Company was held at the Cannon-street Hotel on Friday, 23rd inst., Mr. James Rock, M.P., presiding, in the unavoidable absence of the chairman, Sir John Morris.

With regard to what had been done since the formation of the Company, the **Chairman** said that their General Manager and Mr. Stepney Rawson had been in Austro-Hungary looking for sites for works, with the result that they had provisionally decided upon a site in a good position as regarded raw material and transport. They had acquired the German patents for the Elmore process, and they were in negotiations there for a large manufactory, having available water power to the extent of 550 h.p., besides the steam power on the premises. Mr. Elmore was now in Germany completing the arrangements. They had allotted 50,000 shares, which were very largely paid up. They were allotted to about 580 shareholders.

Resolutions were then proposed from the chair and carried unanimously: (1) Altering the name of the Company to Elmore's

German and Austro-Hungarian Metal Company, Limited, and (2) and (3) making certain alterations in the articles of association required by the Stock Exchange before granting a special settlement.

PROVISIONAL PATENTS, 1891.

JANUARY 19.

912. **Improvements in automatic electric locking gear for controlling signals on railways.** David Richards, 44, Wern-road, Landore, near Swansea.

937. **Improvements to securely attach electrical wires to ceiling roses.** Elijah Atkins and Edward Elijah Atkins, 19, Villa-grove, Handsworth, near Birmingham.

JANUARY 20.

965. **Improved therapeutic magneto-electric mechanisms.** Henry Harington Leigh, 22, Southampton-buildings, London. (Joseph Brown Gardiner, United States). (Complete specification.)

980. **Improved electric signals for railways.** William Walker, Matthew Walker, John Sansom, and Arthur Cole, 39, Guildford-street, Luton, Bedfordshire.

984. **Improvements in telegraphic transmitting apparatus.** Richard Theiler and George Keith Buller Elphinstone, 86, Canonbury-road, London.

991. **An improved electric percussive rock drill.** Albion Thomas Snell, 52, Chancery-lane, London.

1004. **An improved indicator for electric potentials.** Sir Wm. Thomson, 154, St. Vincent-street, Glasgow.

1007. **Apparatus for separating ores and metals by the aid of electricity.** Erminio Ferraris, 89, Chancery-lane, London. (Complete specification.)

1035. **Improvements in primary batteries.** Samuel William Maquay, 55, Chancery-lane, London.

1046. **Apparatus for prepaid telephonic messages.** Robert Howe Gould and Theodor Gottschalk, 46, Lincoln's-inn-fields, London.

1049. **Improvements in the manufacture of dynamo-electric machines.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

1050. **Improved means for distributing electrical energy.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

1051. **Improvements in electrical transformers or converters, and in their manufacture, partly applicable to the manufacture and testing of dynamo and other insulated conductor coils and armatures.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

1053. **Improved method for testing the electrical firing gear of ordnance.** Andrew Noble and Edward William Lloyd, 24, Southampton-buildings, London.

JANUARY 21.

1066. **Improvements in electric blank heaters for forging machines.** George Dexter Burton and Edwin Elliott Angell, 52, Chancery-lane, London. (Complete specification.)

1084. **Automatic throwback for electric indicators.** William Howard Jackson, 3, Brabant-court, Philpot-lane, London.

1114. **Improvements in electric railways and in apparatus for the propulsion of vehicles by electricity.** Albert Churchward, 45, Southampton-buildings, London. (Archibald J. Robertson, United States.) (Complete specification.)

1118. **Improvements in folding lamp shades for gas and electric lamps.** Oliver Imray, 28, Southampton-buildings, London. (Ludwig von Orth and E. Breslauer, Germany.)

1122. **Improvements in or connected with incandescent electric lamps.** Abraham Denby Raine, Norfolk House, Norfolk-street, London.

1138. **An improved guard for incandescent electric light globes.** William Henry Munns, 55, Chancery-lane, London. (Joseph Mino and W. D. Wastfield, United States.)

JANUARY 22.

1173. **Improvements in appliances for the transmission of electric energy.** Sir William Thomson, 154, St. Vincent-street, Glasgow.

1175. **Improved safety ventilating self-lighting gas and electric battens for lighting up theatres and other public buildings.** Joseph Tollerton, 8, Quality-court, London.

1176. **Improvements in brush-holders for dynamo-electric machines and electric motors.** Francis Murray Newton and Tom Hawkins, 46, Lincoln's-inn-fields, London.

1185. **Improvements in cable relays.** Richard Theiler and George Keith Buller Elphinstone, 86, Canonbury-road, London.

1192. **Means and apparatus for propelling boats and rafts on waterways by means of electrical energy.** Otto Büsser, 28, Southampton-buildings, London.

1200. **Electric contact for locks.** William Henry Colson, 37, Chancery-lane, London.

1202. **Improvements in electric clocks.** Marius Devries, 4, South-street, Finsbury.

JANUARY 23.

1250. **Improvements in globe holders for electric and other lighting fittings.** Elijah Atkins and Walter Atkins, 12, Cherry-street, Birmingham.

1251. **Improvements in electrical switches.** Elijah Atkins and Walter Atkins, 12, Cherry-street, Birmingham.

1279. **Improvements in and relating to electric signals for railways.** Edgar Clarence Wiley, James Alexander Dickey, and Napoleon Breedlove Ainesworth, 77, Chancery-lane, London. (Complete specification.)

JANUARY 24.

1329. **An improved electrical heating and cooking apparatus.** William Henry Munns, 55, Chancery-lane, London. (Charles Talmage, United States.)

1332. **An improved insulator for electric wires.** William Henry Munns, 55, Chancery-lane, London. (Fidel Miro, West Indies.)

1339. **Improvements in alternating current electric clocks.** Ernest de Pass, 78, Fleet-street, London. (Heinrich Christian Spohr, Germany.)

1350. **An improved galvanic belt.** Charles Andrews, 175, Wardour-street, London.

1359. **Improvements in or relating to electrical fire signals.** Alfred Julius Boult, 323, High Holborn, London. (Charles Dixon and — Fouler, France.)

SPECIFICATIONS PUBLISHED.

1889.

20652. **Incandescence electric lamps.** Edmundson and Clarke. 6d.

1890.

3732. **Electro locomotives.** Hopkinson. 6d.

18491. **Dynamo electric machines.** Kennedy. 8d.

19406. **Electric current meters.** Hartmann and Braun. 6d.

CITY NOTES.

Brazilian Submarine Telegraphs.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ended January 23 were £6,367, and those of the Western and Brazilian Telegraph Company, Limited, £5,195.

Woodhouse and Rawson United, Limited.—The resolution which was passed at the extraordinary general meeting on January 9, increasing the capital of the Company to £550,000, was unanimously confirmed at a meeting held this week.

Western Union Telegraphs.—The numbers are announced of seven bonds of £200 each and six bonds of £100 each of the Western Union Telegraph Company 6 per cent. sterling loan, to be paid off on and after March 2, by Messrs. Morton, Rose, and Co., Bartholomew-lane, E.C.

Electricity Supply Company for Spain.—The Electricity Supply Company for Spain, Limited, invite applications to Messrs. Martin and Co. for an issue of £75,000 in 6 per cent. mortgage debentures at 98, which will be secured by a first mortgage (in favour of trustees) on the Company's freehold land, buildings, and machinery, and by a floating charge on all the Company's other property.

Anglo-American Telegraph Company.—The report of the Directors of this Company shows that the total receipts from July 1st to December 31st, 1890, including £2,793 brought forward, are estimated at £161,986. This amount, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending before the Council of State. The traffic receipts show an increase of £3,027, and the total expenses, including repair of cables, etc., amounted to £56,142. Interim dividends of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred stock were paid on the 1st of November last, absorbing £52,500, leaving a balance of £53,344, out of which the Directors recommend final dividends of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred stock, making a total distribution for the year ended December 31st of £2. 17s. 6d. per cent. on the ordinary and £5. 15s. per cent. on the preferred stock, leaving £844 to be carried forward.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	1½
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	7¼

NOTES.

Death of Otto.—The death is announced from Cologne of Herr Otto, the original inventor of the celebrated gas engine of that name.

Glasgow Theatre.—In the redecoration of the Glasgow Gaiety Theatre, just reopened, electricity has been employed for illumination.

Barnsley.—The Town Council have received tenders for their electric light station, and have adjourned the consideration of them to the next meeting.

Dublin Railway.—There is now a continuous connection of Dublin with the Kingstown pier. The carriages are of the best quality and are lighted by electricity.

Berlin Theatres.—The police have requested every theatre and place of entertainment in Berlin capable of containing more than 800 persons, to be lighted by electric light.

Consulting Engineer.—Mr. Reginald P. Wilson, late of the London Electric Supply Corporation, has taken offices as consulting engineer at 3, Princes-mansions, Victoria-street.

Folkestone.—Mr. Councillor Logan has given notice that at the next meeting of the Corporation of Folkestone he will revive the question of lighting the town streets with electricity.

Institution. — The discussion on Major-General Webber's paper on "The Distribution of Electricity, with especial reference to the Chelsea System," took place before the Institution last night.

Ripon.—The Water Supply Committee of Ripon have had under consideration an agreement with the Marquis of Ripon for the lease of water power for the purpose of providing Studley Royal with the electric light.

Honours.—The Queen has given orders for the promotion of Sir Frederick Abel, C.B., President of the Committee of Explosives, War Department, to the dignity of a Knight Commander of the Order of the Bath (Civil Division).

The Brush Company. — Mr. E. Garcke, formerly manager and secretary of the Brush Electrical Engineering Company, Limited, has been appointed a managing director of that company, and Mr. B. Broadhurst succeeds him as secretary.

Bromley.—The South-Eastern Railway Company have notified their intention of opposing in the House of Parliament the provisional order passed by the Board of Trade on the application of the Bromley Local Board for electric lighting powers.

Utilising the Swiss Rivers.—The Municipality of Zurich have had before them the request of a syndicate for a grant of permission to utilise the River Reuss, which they propose to employ for the transmission of power electrically to the surrounding districts.

Duties on Chemicals.—The Paris General Customs Committee on Feb. 2 adopted a new scale of duties upon chemical products. Sulphuric acid will be exempt, and nitrate of potash will pay two and three francs per 100 kilos, and caustic soda six and eight francs.

Electric Photography.—M. Lafayette, photographer, of Glasgow, is reputed to have a 10,000-c.p. arc lamp for use in dark weather, and at night, mounted on a portable stand with flexible cables. The current is supplied from 61 storage cells charged by a gas engine and dynamo in an adjoining room.

Erith.—The Erith Local Board have appointed a committee to consider the question of the future lighting of the area over which they have control, and as both gas and oil lighting have been tried and voted failures in this locality, special consideration will be given to the desirability of adopting the electric light.

Electric Standards. — The Electrical Standards Committee held their second meeting at the Board of Trade on Saturday last. The following members were present—viz., Mr. Courtenay Boyle, Major Cardew, Mr. Preece, Mr. Graves, Lord Rayleigh, Sir W. Thomson, Prof. Carey Foster, and Dr. Hopkinson.

The Postal Telegraphs.—On February 5th, 1870, the undertakings known as the United Kingdom, the Electric, and British and Magnetic Telegraph Companies were transferred to the Government. Yesterday (Thursday), therefore, the Postal Telegraph Department celebrated its twenty-first birthday, or, in other words, came of age.

Indian Telegraphs.—Something like 1,800 miles of wire were added to the great network of Indian telegraphic communication last year, and the department reports a profit on the operations of the year amounting to about 21 lakhs of rupees. An analysis of the returns show that while the inland telegrams increase rapidly in number the messages are more and more curtailed.

Chatham.—In consideration of the company having already spent £10,000 in supplying the electric light, the Chatham Local Board of Health have resolved to recommend the Board of Trade to accede to an application of the Chatham, Rochester, etc., Electric Lighting Company to be released from the engagement of depositing £500 as a guarantee for the fulfilment of the provisional order.

Staircase Lighting.—In several houses in Berlin let in flats, an ingenious arrangment of temporary electric lighting has been installed, for the advantage of late comers who enter after the extinction of the light in the hall. When the outer door is opened a light starts up and remains alight while the tenant is below, and as he mounts, the various flights of stairs are illuminated one after the other.

Ship Lighting.—Messrs. David J. Dunlop and Co., engineers and shipbuilders, Inch Works, Port Glasgow, have launched from their yard a handsomely modelled awning-deck passenger steel screw steamer built by them to the order of Sobrinos de Herrara, of Havana, for their coasting service between Havana and Porto Rico. The vessel will be fitted throughout with electric light, including a powerful search-light.

The North Riding County Council have resolved: "That it be an instruction to the Highways Committee that, when applications are received to erect either telegraph or telephone posts by the side of their main roads, the committee inform the applicants that the County Council have no power to grant such permission, but that if such posts are erected they will be at the risk of the applicants."

Personal.—Mr. Orlo. V. Thomas, A.I.E.E., has resigned the position of managing electrical engineer to the Taunton Electric Lighting Company, Limited, and has been appointed by the Crown Agents for the Colonies to take charge of the installation at Singapore. The electrical staff of the company presented Mr. Thomas on his leaving them with a photograph of themselves in a handsome frame of oak, bearing an inscribed silver shield.

House Electricians' Handbook.—We received some time back an illustrated handbook in German issued by the

Mix and Genest Company, containing a vast amount of information upon subjects connected with house bells, telegraphs, telephones, lightning conductors, and all other electric arrangements for domestic use. The necessity for issuing a second edition within two months is, perhaps, the best proof of the usefulness of this little work.

Electric Light Installation near Ascot.—Sunningdale Park, near Ascot, which has recently been acquired by Major Joicey, is to be electrically lighted throughout. It is estimated that about 350 lamps will be required to light the house and stables, and the generating plant will comprise two Cornish boilers, and two Parsons steam turbine-dynamo machines of the new improved type. The installation is being arranged by Mr. A. A. Campbell Swinton.

Old Students' Paper.—A paper will be read before the Old Students' Association, at Finsbury College, Leonard-street, on Wednesday, February 18, at eight o'clock, by Duncan Pearce, member (hon. treasurer), entitled "From College to Factory," being the contributor's experience in the so-called department of theory and practice. It will be divided into the heads (a) Present defections of both from an ideal; and (b) Suggestion for making up the deficiencies, with the object of making manufacture a profit and pleasure.

The s.s. "Panama."—The fine screw steamer "Panama" has just sailed from the Tyne for Cadiz. Messrs. Wigham Richardson and Co., of Low Walker, have entirely reconstructed and fitted her as a first-class mail steamer. The ceiling is divided into panels and decorated in white and gold with a soft French tint. The vessel is fitted with the electric light. The ladies' boudoir is finished in a very artistic manner, the fringes and velvet being of old gold. The state and other rooms are in keeping with the other fine furnishings.

Manchester.—In the Manchester City Council on Wednesday, Mr. J. Brooks stated that the Electric Lighting Sub-committee were making progress in reference to the lighting of a prescribed area with the electric light, and very shortly they would submit a report as to the manner in which the work should be done. At a later stage of the proceedings, the Mayor intimated that arrangements were in progress for putting the electric light throughout the Town Hall. When that was done, the ventilation, he thought, would be greatly improved.

Leeds Tramway.—Leeds is to have its electric tramway on the Roundhay line begun very shortly. The Highways Committee have reported that steps were taken to hasten the accomplishment of the scheme. It was stated that the Thomson-Houston Company, who are to work the service, were doing all they could to expedite matters. They had, it was reported, been before the Board of Trade, who had agreed to everything, with the exception of a few minor details, and when these had been disposed of the work was to be commenced forthwith.

Sites of Central Station.—According to the *Elektrotechnische Zeitschrift*, the simplest method of determining the best site for a central station will be to find the centre of gravity of the system, taking the values of various points in the area as proportionate to the density of current to be supplied at these points, in which case the total weight of copper in the feeders will be at the minimum. This calculation will, however, have to be modified when the considerations of cost of site and rent and, it may be, cost of cartage of fuel and so forth, are taken into account.

Leeds.—On Friday, at a meeting of the Sub-Parliamentary Committee (Electric Lighting) of the Leeds County Council, the question of the three applications which have been made for provisional orders to supply electric light in the town by private companies was discussed at considerable length. The town clerk explained the legal position of the Corporation, and the borough engineer gave some further information on the subject. Ultimately, any decision was postponed, pending which Mr. Hewson, the borough engineer, will get together further information.

Canada.—The attention of certain manufacturers of electrical apparatus might be very well turned to Canada. From recent information we have received from this great colony we hear that nearly every town of any pretension has its public and private lighting, and incandescent lamps are common in most houses of the well-to-do classes. But there is a great want of pretty and artistic fittings; very little but the most common-place and ugly fixtures are to be obtained as a rule. This may be a hint that our readers may be able to take up, and rectify so great a lack of beauty in fittings.

Edinburgh. — The Corporation of Edinburgh have replied to certain objections raised by the Corporation of Leith in the form of a parliamentary paper. With the view of meeting the objections stated for the Corporation of Leith, the Corporation of Edinburgh are ready to consent to a provision being inserted that the Gas Commissioners should not be entitled to accept any transfer of the powers of the Corporation under the order, except by a vote of at least three-fourths of the Gas Commissioners, and except with consent (1) of the Corporation of Edinburgh and (2) of the Corporation of Leith.

Steam v. Electricity.—An electric car at Brockton, Massachusetts, the other day came into collision with a railway train on a level crossing. The car was overthrown, and six women who were riding in it were injured, two very seriously. Stephenson's old saying "Bad for the coo" (or car) still holds good. It would have been the other way, however, if Mr. Weems's 400 mile an hour car had been the electric representative in the contest. We trust, however, that as electric traction increases, a great deal more care will be taken at American level crossings to avoid accidents between the two rivals.

Electrical Transmission in Wurtemburg.—The first electrical power in the province of Wurtemburg has just been put into operation in Königsbronn, where steam power has been replaced by electric power in the Royal Foundry. The installation has been carried out by the Esslingen Engineering Works. It contains a turbine which drives a dynamo at 600 revolutions per minute, and which gives 40 e.h.p. The current from this dynamo is transmitted by means of overhead conductors across the town to the Royal Foundry, where 25 turning lathes and polishing machines are actuated by electromotors.

Aberdeen.—On Tuesday, the Gas Sub-Committee of the Town Council of Aberdeen, instructed Mr. Smith, superintendent of the gas works, to report as to the sum which it would cost the Corporation to introduce electricity within the compulsory area defined in the Aberdeen Electric Lighting Order, 1890, and the amount for which an electric lighting company would work the undertaking. At a recent meeting of the Gas Committee, a letter was submitted from the manager of the Great North of Scotland Railway Company enquiring as to when the Town Council would be in a position to supply electricity, and the cost. The sub-committee are ascertaining the probable number of consumers of the light.

Newcastle.—At Wednesday's meeting of the Newcastle Town Council, Alderman Winter presented the report of the Town Improvement Committee as to the negotiations which have been going on between the committee and the Newcastle District Electric Lighting Company. The Council adopted the committee's recommendation to consent to the company's proposed provisional order on condition that the Corporation should have the option of purchase at the end of 31 years, instead of 42 years, from the commencement of the order, and that the maximum rate of dividend of 8 per cent. (cumulative) and all profits above such dividend, should be equally divided between the consumers and the shareholders. These terms have been agreed to by the company.

Blackfriars Bridge.—In the Chamber of Common Council on Jan. 29, the town clerk read a letter from the clerk of the Commissioners of Sewers, stating that the Commissioners had arranged with the Brush Electrical Engineering Company, subject to a contract being executed, to light the western district of the City; that the company were anxious that Blackfriars Bridge might be included in their area of supply, and that the Commissioners had referred them to the Corporation as the owners of the bridge, and desired to commend the application to the favourable consideration of the Court. Also a letter from the Brush Electrical Engineering Company making an application accordingly. It was decided to refer these two letters to the Bridge House Estates Committee.

North Metropolitan.—At the meeting of the North Metropolitan Company, allusion was again made to the difficulty with absurd regulations of the authorities at West Ham. There was not much encouragement to go on with electric traction until they were perfectly sure they would not be called upon to cease its use at 24 hours' notice. As will be remembered, the company are pressing forward a Bill in Parliament. The London County Council has given them powers for use of electricity for seven years without any absurd restrictions, and the object of the Bill was to obtain similar privileges from the West Ham authorities. If the latter gave them the same terms as the County Council they would not go on with the Bill, but if not they would continue their application to Parliament.

Hong Kong.—The Hong Kong Electric Light Company successfully commenced lighting the streets of Victoria (the chief town of the Island of Hong Kong) at the beginning of December last. The Hong Kong paper says "The light is beautifully bright and as steady as that of Old Sol himself. We congratulate Mr. Wickham (the manager) on bringing the undertaking to so successful an issue." The town is lighted up by about 90 arc lamps—60 on one circuit and 30 on another. These are Brockie-Pell double-carbon lamps, burning 32 hours, and is the first general application of these long-burning lamps to public lighting. There is great economy of carbons, besides the desirability of having so great a stand-by in case of fogs and darkness. The first pair of carbons are burnt right out before the second ones change over, and the lamps are trimmed usually only every other day.

Overhead Wires.—Mr. T. J. Haughton, of 27, Piccadilly, writing to the *Standard* on Tuesday, says: "At eleven o'clock on Sunday night I was walking up Regent-street from Waterloo-place. On reaching the entrance to York House (Junior Army and Navy Stores), I saw two ladies and a gentleman endeavouring to extricate themselves from a tangle of some kind, and before I had gone two paces further found I was likewise entangled. I stopped immediately, and found that it was a fine steel wire that stretched across the street, and had some difficulty in hauling it in, owing to the pressure of vehicular traffic. Roughly judging, I would say there was not less than 40 yards of it. I summoned the constable on duty at the junction of Jermyn-street, when we found the wire was fast to some upper storey of York House. The matter certainly wants explaining."

Arc Lighting in Australia.—The Government wharves at Sydney are lighted by Brockie-Pell arc lamps. The New South Wales Government are also about to light up the whole of the wharves at Bullock Island, near Sydney, with 50 of the same arc lamps. The town clerk of Port Augusta, the port of Adelaide (Mr. J. Holdsworth), writing recently, states that the two 3,000-c.p. Brockie-Pell arc lamps have been and are most successful. They are burnt outside the town hall, and the light is the steadiest he has yet seen in the colony, and is admired for its excellence by all visitors to the town. Flickering is conspicuous by its absence, and after three years' use the lamps seem to be equal to new. Such good reports as these must be flattering to the makers, and we hope will lead to a far greater extension of arc lighting in other parts of the British empire abroad.

Edinburgh Tramways.—At the meeting of the Edinburgh Tramway Company allusion was made to the mention of the Corporation taking over the lines in 1892. No official notice has been sent, and the directors, therefore, had put themselves into active communication with the various local authorities interested, with the object of having the company's powers prolonged on terms which might include an increase of capital for extension of the lines. The question of traction or motive power might also be involved. There were difficulties in the way of applying either the cable system or electricity to the company's lines. Regarding electricity, they did not know yet whether it was suitable for their steep gradients, and if so, at what cost it could be worked. In conclusion, the chairman moved the adoption of the report, with the recommendations therein, which were carried.

The Lighting of Sophia by Electricity.—A contemporary publishes the following particulars in reference to this contract: The plant was to be installed at the Government printing office, and current was to be supplied to the Palace about half a mile away, and to the Sobranje, 286 yards distant. The total light required was estimated at 12,500 candles by arcs, and 25,000 candles by incandescents. A storage battery was to be employed as a reserve. The following is the list of tenders for lighting the town by electricity:

Egger and Co. (accepted)	£9,328
Ganz and Co.	9,535
Schuckert	9,768
Siemens and Halske	11,158
Sautter-Harle	11,600
Société Gramme	13,440
Kremenezky	13,500
Compagnie Continentale Edison	15,120
Compagnie Continentale Edison	15,881
Crompton and Co.	11,120
Crompton and Co.	15,290
Allgemeine Elektricitäts Gesellschaft	15,940
Southgate Engineering Company	16,896
Société d'Appareillage Electrique (Paris)	18,000

Liverpool Overhead Railway.—This railway will be a double line for passengers only. It is to extend from Fort-road, Seaforth, at the north end of the dock estate, to the Harrington Dock at the south—nearly seven miles. At first steam was proposed as the means of propulsion for the trains, but the progress of electric science now renders it probable that steam will be abandoned and electricity substituted. On this head, however, a decision has not yet been made. A traffic of over 5,000,000 persons is confidently expected for the first year. The chief engineers are Sir Douglas Fox and Mr. G. H. Greathead; the resident engineer is Mr. Francis Fox, who has as assistants Mr. Ernest Wilcox and Mr. S. B. Cattrell. Mr. J. W. Willans, of Manchester, the contractor, has had previous experience in railway construction, having been connected with the subway in London, recently opened by the Prince of Wales. There being no engineering difficulties in the way, progress with the new line is fairly rapid. It is complete from Fort-road to the Alexandra Dock. The foundations are laid for another two miles, and upon these the columns have been erected for nearly a mile.

Electric Preparation of Hydrosulphite of Soda. Hydrosulphite of soda is a salt not much used in commerce; it is almost exclusively used in dyeing, either to lighten indigo tanks or to bleach silk or wool. It is almost always prepared by the Schützenberger process, which consists in making zinc react upon a solution of bisulphite of soda. These manipulations are long, and the cost is high. An electric process has been described by M. Villon, both more rapid and cheaper than the present one. The bisulphite of soda is reduced by the electrolytic hydrogen; 88 kilogrammes of bisulphite of soda, require to be completely transformed, three kilogrammes of hydrogen instead of two, the theoretic figure. The operation is carried out in a pine trough with porous earthenware divisions: one compartment contains the negative carbon electrodes in 300 litres of bisulphite of soda at 35deg. Beaumé; the positive electrodes dip into a solution of sulphuric acid diluted with 10 times its volume of water. The trough is hermetically sealed, and the current is passed until four kilogrammes of hydrogen is formed. This operation takes 350 horse-power hours. The hydrosulphite is then ready for use. The net cost of these 300 litres is 6f.

Tramway Legislation. — Now that electrical engineers are likely to go in for tramway work it might be of use for them to give some attention to the state of the Tramway Acts, which was the subject of the discussion at the British Tramway Institute. It was obvious, maintained the president (Mr. W. J. Carruthers Wain, C.E.), that within the limited time allowed by the Act of Parliament, it was impossible for any company, however favourable the circumstances, and however well managed, to build up such a reserve as should take the place of the ordinary capital, and be able to repay it at the end of 21 years. There was no tramway company in this kingdom or in any other which could do it. After expending a large sum of money in the construction of an undertaking for the public benefit, and after having received only a very limited profit, perhaps none at all, the Legislature never contemplated that the whole of the money invested should be absolutely confiscated. He thought they would agree with him that it was absolutely necessary that one of the first points to which the committee he suggested should direct their attention with regard to legislation for the future of tramways, should be a clear and distinct definition of the price at which a tramway should be sold if a local authority wished to buy it. The resolution was moved and adopted: "That it be referred to a committee, consisting of the president and vice-presidents, to consider what action should be taken with a view to early legislation to amend the Tramways Act, 1870."

London County Council.—At the meeting of this body on Tuesday, the report of the Parliamentary Committee was brought up. It contained the following recommendations as regards the Central London Railway Bill: "(1) That a petition be presented against the Bill, with a view to the protection of the sewers and other interests of the Council, and for the insertion of clauses prohibiting buildings in advance of the general line, or such other provisions as will prevent traffic accumulating on the pavements at stations, and subjecting buildings over stations to the Building Act, and requiring the frontage line of buildings at the stations to be set back." This was adopted. Also (2) "That the Council's petition should contain a provision asking that clauses for the ultimate purchase of the undertaking by the local authority, similar to those at present contained in the Tramway or other Acts, be inserted in the Bill." The following amendment by Mr. Saunders was adopted—viz.: "That it be an instruction to the Parliamentary Committee that, in the event of the owners of land adjoining the line of the proposed railway seeking to obtain clauses in the Bill which would authorise them to obtain payment in respect of ground under the surface, the Council shall strenuously oppose the insertion of such clauses, which, if admitted, would establish a precedent seriously prejudicial to the interests of the inhabitants of London." With regard to the City and South London Railway (Islington Extension) Bill, the committee made similar recommendations; and also recommended that a petition be presented against the preamble of the South Kensington and Paddington Subway Bill.

Electric Light at Durham Cathedral.—During the past week a series of experiments have been made in connection with the lighting of Durham Cathedral by electricity with thoroughly satisfactory results. Messrs. E. Scott and Mountain, of Newcastle, erected a trial installation for the Dean and Chapter, and the choir was illuminated with 48 16-c.p. incandescent lamps, 12 being affixed to each of the choir candelabra, and 12 to each of the gas standards within the altar rails. The illumination was far superior to that afforded by the present gas lighting arrangements. One of Messrs. Scott and Mountain's Tyne compound dynamos, driven by a small vertical steam engine, was placed in the stone yard, and the current conveyed by means of cables to the fittings in the choir. It is proposed to extend the electric light throughout the entire cathedral, the present experiments being for the purpose of determining the actual quantity of light required and the best arrangement of the lamps. If the results are deemed satisfactory, the Dean and Chapter will proceed with the scheme of lighting the cathedral by electricity. In the event of the scheme which has been proposed by the electricians being adopted, the River Wear will be utilised to work the turbines, which will provide the necessary power not only for lighting the cathedral, but also the residences in the college. If this scheme is adopted, it is proposed to put in accumulators of ample capacity to supply the current to the cathedral and to the houses, to provide an ample safeguard against any possible failure of the light. In addition to this, the scheme provides a dynamo of sufficient power to run the whole of the lights, so that under ordinary circumstances the accumulators would not be required. But the method proposed is to charge the accumulators during the day and utilise the stored current for the cathedral services and the canons' residences in the evening. If the scheme is adopted, the nave will be lighted by five candelabra similar to those in the choir, each of which will have 20 lights. Each transept will be similarly lighted.

The Westinghouse Company. — Rumours of a startling character have been bandied about with reference to the great Westinghouse Electric Company, and it has been necessary to make known that a financial crisis was to be feared. The long years of costly litigation, of growth of an enormous business beyond safe limits of cash capitalisation, and the acquisition of important but costly rights, have run the company, in a word, short of current cash, and Mr. Westinghouse has shown a disposition to throw in his private fortune by securing a loan of half a million to tide over the difficulty. The bankers into whose hands the matter came felt the business to be too un-familiar to them to accept this arrangement, and it has been decided to issue preferred stock to raise funds to meet the exigencies of the business. The creditors show a disposition to help the extraction from the present difficulties, and the negotiations for the stock are progressing to a satisfactory conclusion, and there is good reason to believe that confidence in this corporation, which has certainly done so much to spread electrical work and has carried out enormous and profitable business, will be restored. In an authoritative statement, given by request of George Westinghouse from himself to the *Electrical World*, it is pointed out that there are eight distinct corporations unconnected with each other except through the ownership of Mr. Westinghouse of a controlling interest in each. The Westinghouse Air Brake Company, the Union Switch Company, the Westinghouse Machine Company, the Philadelphia National Gas Company, the Standard Underground Cable Company, the Allegheny County Light Company, the Fuel, Gas, and Manufacturing Company, and the Westinghouse Electric and Manufacturing Company. Of all these it is the last only that is in financial trouble. All the capital it requires can be secured by the placing of from thirty to forty thousand shares of the par value of 50dols. each of its preferred stock, either for cash or in settlement of outstanding obligations. Mr. Westinghouse is now devoting himself to the placing of this stock, and is very hopeful of success. The total sales of all of the companies named amounted in 1890 to over 15,000,000dols.

Mr. W. J. Hammer's Debut.—One of our pleasantest recollections from the time of the Paris Exhibition, and indeed of other times, is of Mr. W. J. Hammer, Mr. Edison's manager, engineer, general superintendent, and designer of the Edison exhibits in Europe and elsewhere. Mr. Hammer is one of those men who make everything go; genial, full of knowledge and varied experience, and full of resource, having held important positions in the practical as in the commercial part of those huge Edison electrical companies whose rise is such a feature of American work. Often called upon to go here and there over the world, on their behalf, at a few hours' notice, and to engineer, arrange, and supervise large and varied installations, Mr. Hammer has, perhaps, made his name more known by his original and striking arrangements for the great exhibitions than almost any other modern man. From an ingenious and equally striking and original prospectus that we have just received from Mr. Hammer, we notice that he has set up an office and career of his own, as consulting and supervising engineer; thinking, and no doubt rightly, that so great is the advance of modern electric science that capable and independent advisers to those who wish to introduce the latest applications of electricity will have as much scope as have architects and consulting engineers. Mr. Hammer, to illustrate his capabilities in this direction, issues specimens and testimonials in as tasty a way as he can devise. Photographic reproductions of the Paris exhibits, the novel electric displays at Cincinnati, the Crystal Palace, and the Franklin Institute are given, together with the famous Ponce de Leon Hotel at St. Augustine, Florida, which was placed under his control, and for which he designed novel scenic effects in the grounds. Mr. Hammer also characteristically reproduces original letters of laudation and acknowledgment from what he terms the "crowned heads" of electrical science—Edison, Elihu Thomson, Frank Sprague, and the presidents of the Edison and Westinghouse Companies, with a specimen digest from an elaborate report prepared by him as chief inspector of central stations to the Edison Company, embracing tests of engines, boilers, dynamos, and apparatus in minute detail. To finish, there is given a most amusing and interesting account of a New Year's entertainment given at his own house, where every conceivable effect, dodge, scene, useful, beautiful, and startling application of electric light and force were concentrated, to the bewilderment and wonder of the guests. We wish Mr. Hammer all success in his new sphere, and doubt not that he will achieve it.

Birmingham.—Before the Birmingham City Council on Tuesday the report of the Public Works Committee was submitted, dealing, amongst other things, with the application to the Board of Trade of the Birmingham Electric Supply Company. In moving the adoption of a recommendation that the Council consent to the application, subject to the insertion of clauses giving effect to certain alterations proposed by the committee, Mr. Parker said that the order was for the purpose of obtaining certain small extensions of the area included in the order of 1889. The object of including these supplementary areas was that they would give more convenient access to the properties which the company were proposing to light, and with less disturbance of important streets for the laying of mains, etc. The committee were anxious to guard against the company obtaining more than was reasonable and right, and had obtained their consent to give up two areas which the committee did not think it was necessary for them to acquire. With these omissions the order asked for would give a more compact area wherein to try their experiment. Alderman Pollack having given statistics as to the progress of electric light in London and elsewhere, Alderman Avery asked whether the adoption of this resolution would not affect the possibility or the probability of the Council becoming the electric lighting authority. Mr. Lancaster agreed with Alderman Pollack that the Council should take up electric lighting, but he did not think that electricity as an illuminant would always be dearer than gas. He thought that the resolution meant giving the company the finest plum in the matter of electric lighting area. He believed that by-and-by the Council would take over the works and provide electric lighting for the whole town. Mr. Barclay thought the Council ought never to have allowed the matter to pass out of its own hands. Mr. Fallows thought that when the concession was granted to Messrs. Chamberlain and Hookham the Council took power to acquire the undertaking in a certain time. Mr. Beale reminded Mr. Barclay that if the Council had not given their consent to the provisional order, the Board of Trade might have taken the matter out of their hands. What was proposed now was not to give the company any additional area, but to make the area already granted more useful, not only to the company, but to the city, Mr. Parker, replying, said that there was a good reason why each one of these additional areas should be given on its merits. The committee quite agreed to what had been said as to the desirability of doing nothing which would prevent the Council from becoming the electric lighting authority. They had to bear in mind that they had, both this session and last, given the Board of Trade to understand that they would not prevent anybody having powers in Birmingham, but that they desired to see the experiment tried, and proposed the resolution to give all reasonable facilities for the purpose. The additions to the area were to ensure as little disturbance to New-street as possible, and another reason was that the present company's station was in Dale End, whereas Messrs. Chamberlain and Hookham, the original *concessionaires*, intended supplying the area from Bartholomew-street; and another was to facilitate the lighting of the Victoria Courts. The motion was agreed to.

UNDERGROUND MAINS.—III.

THE CALLENDER-WEBBER SYSTEM.

(Continued from page 123.)

The actual process of laying the Callender-Webber mains is as follows:

The course of the main is first laid out, and the trench dug to the required depth. The trench is made in as straight a line as possible, and is somewhat carefully levelled, a good foundation being secured by ramming down the soil. Occasionally rough concrete is employed in the trench to bed the conduit, but this is necessary only in exceptional circumstances. As long lengths as are permitted by the authorities are opened at a time, arrangements being made to avoid interference to the traffic by bridging the trench where necessary. At crossings, however, the work is done in short sections to avoid blocking the traffic. The surplus earth is everywhere carted away regularly.

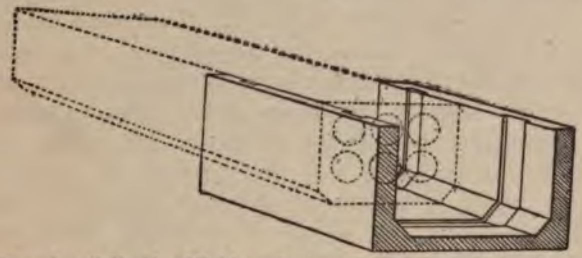


FIG. 5.—Callender-Webber Casing Joint with Saddle Piece.

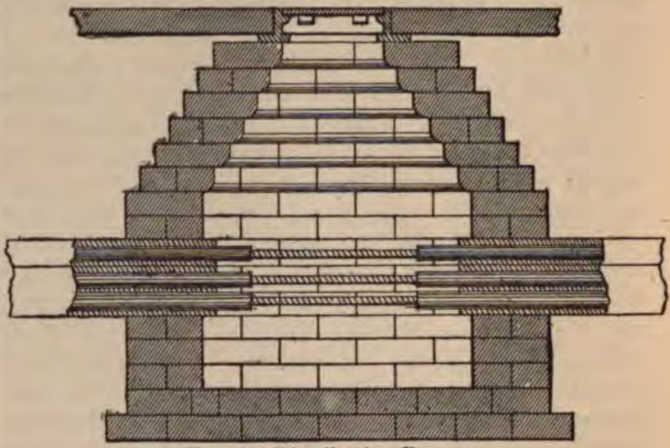


FIG. 6.—Distributing Box.

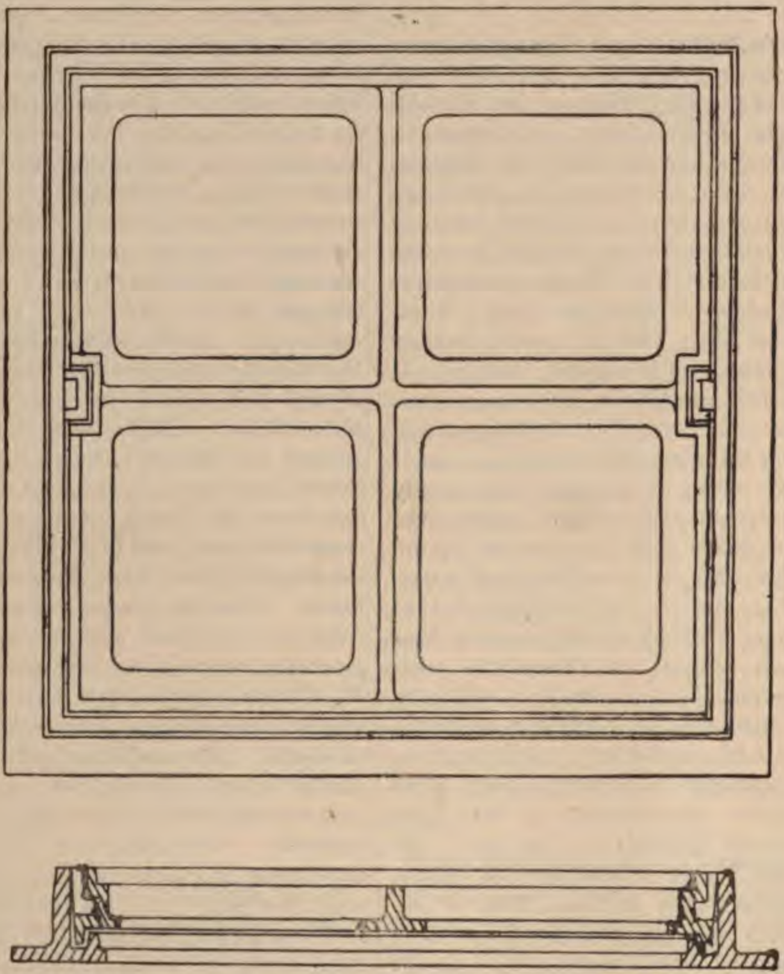


FIG. 7.—Detail of Coverplate.

The bitumen casing is next laid upon the bottom of the trench and jointed together. This jointing is carried out length by length to form one solid and continuous casing. Each fresh 6ft. length is placed on the ground, with 2in. to 3in. interval between it and the one already laid. In the meantime some bitumen concrete is being heated in the large iron cauldrons. Mandrels are pushed through each of the holes in the casing, joining the two sets of holes together. Then the bitumen concrete is run in, stamped into position, and shaped into the same shape as the original casing. The joint is thus made absolutely waterproof, and the mandrels ensure the holes being smooth and continuous; the result is practically one solid bitumen casing, and except for the newness of the material, a person passing along can hardly tell where the joint has been made. The mandrels are then pulled out, the earth thrown in again, rammed down, and the road repaved.

In certain circumstances where the mandrels cannot be used, a different method is adopted. The ends of the casing are butted together (see Fig. 5), and saddle pieces of material similar to the case itself are placed at the joint, which is made tight by a little bitumen seared with a hot iron.

The next detail is the construction of the drawing-in boxes.

These are constructed in a simple manner by the building of a pit in brickwork at the places required, in the manner shown in Fig. 6. In the larger sizes these are made 3ft. by 3ft., and about 4ft. deep. The bottom is not concreted, but left in ordinary brickwork, so that any moisture that may get in may easily drain away. The walls of the pit are built up, and the bitumen casings are so arranged that they project about 6in. into the pit. Above them the brickwork, overlaid and tapered up, as shown, forms a manhole in the surface of the street, having a cast-iron box and removable lid.

The cover plates are generally made 18 by 12, 20 by 15, 24 by 15, or 24 by 24 inches, according to the size of the pit. The plate on the footpath is filled in with cement to resemble the paving in which it is placed. In some cases, where access is not often required, it is often found desirable to seal in these boxes. For this purpose the boxes are cast in a special form (see Fig. 7), so that a second lid can be placed on the inner rim there seen under the pavement lid, and the box then made absolutely watertight by sealing in the false lid with red lead or asphalte.

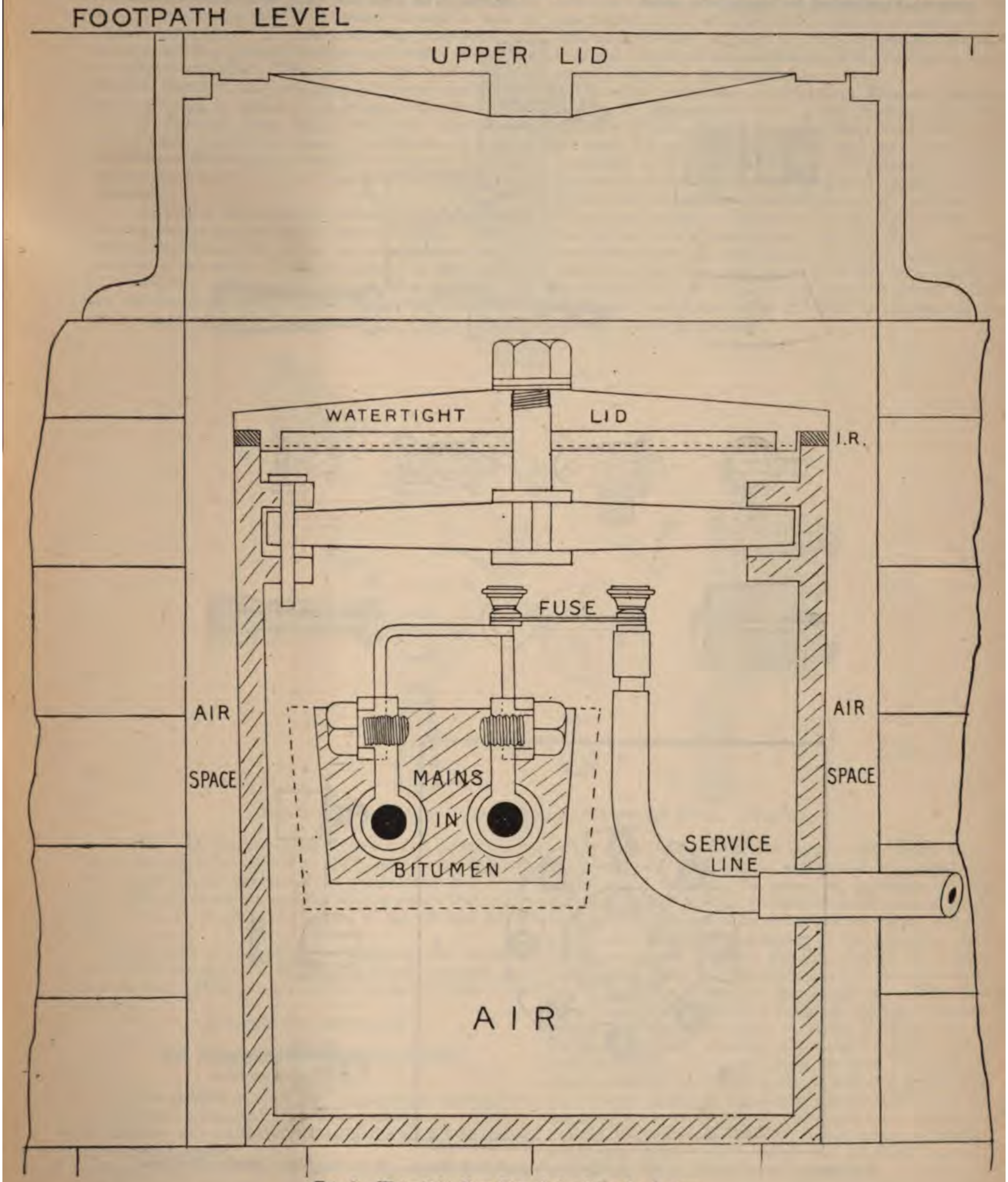


Fig. 8.—Watertight Fuse Box of the Callender System.

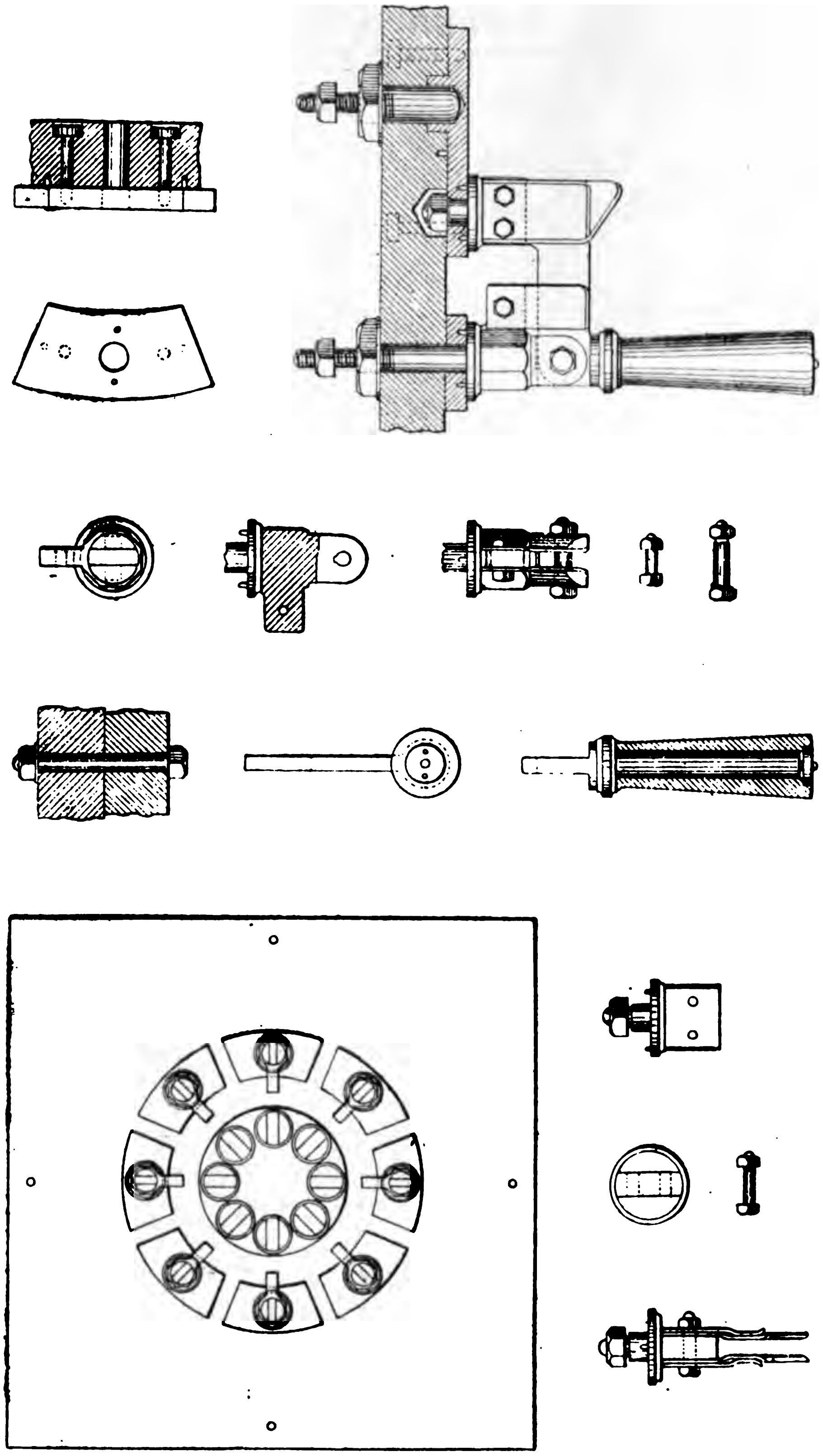
Three different kinds of boxes are in use :

1. Feeder boxes, for the connecting of feeders to distributing mains.

2. Service boxes, for the connection of mains to cus-

tomers' mains at points where large supplies of current are to be taken off.

3. Supply boxes, for the supply of householders, put in, if required, when service boxes are too far away. These latter are usually constructed of cement or brick built round the conduit after it is laid, so that the conduit is cut at the point most convenient for tapping the cables.



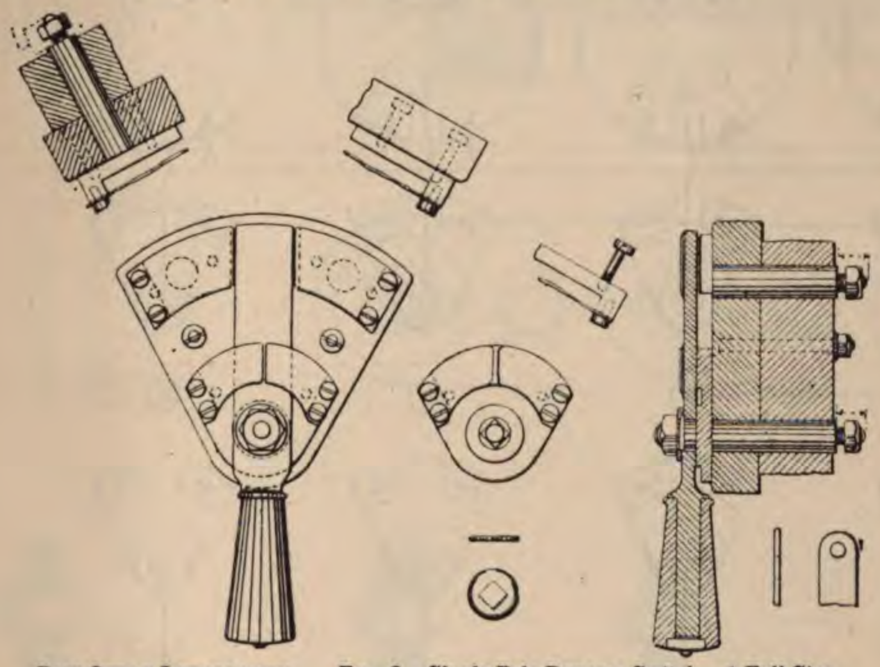
Post Office Installation. Fig. 1.—Engine Room Switch Board. Plan ⅛ Full Size. Details ¼ Full Size.

When the conduit is all laid and the various boxes properly built, the drawing-in of the cable itself follows next. In the smaller sizes of casing a cord is passed in as the conduit is laid. The mandrels are specially made with a hook at the end, to which the cord is fastened as each length of casing is laid and the mandrel withdrawn, the cord is therefore drawn through. With the larger sizes of holes such a precaution is not necessary, and when the conduit is laid a jointed rod—something like a sweep's rod—can easily be pushed through from box to box. This is attached to a cord, which in its turn is drawn through and pulls in a rope. The rope is attached to a cable, which is pulled in either by a number of men hauling or by the aid of a winch. The ways are quite smooth inside, and 500 or 600 yards (⅓ mile) in one length of cable can be drawn in without any great difficulty. Lengths such as these would only be used for feeders or for supply mains in the country, and for town supply the lengths would be of from 50 to 100 yards, or often less where the demand was heavy and service boxes numerous.

The cables that are used are Callender cables of high insulation with dielectric of vulcanised bitumen, and are made as follows: The conductor is of stranded copper cable of not less than 98 per cent. conductivity. This is first covered by a solid sheath of bitite (bitumen vulcanised under the Callender process) put on under heavy pressure at one operation. This core is then served with tape and insulating compound, and again served with either jute yarn or additional tapes, finally braided with hemp yarn and passed through a bath of asphalte compound. The cables are thus made extremely durable, resisting perfectly themselves all action of moisture or coal and sewer gas. When laid in the solid casing of bitumen, therefore, they are practically indestructible. The bitumen is also, it appears, a thorough protection against rats, for although these mains have been laid now for several years, the rats have never been found to bite either the cables or the casings, although it is known they have made in some cases the spare holes in the casing their mode of travel.

In connecting the mains to branch or service supply circuits, the course is often adopted of building what are termed fuse-boxes, Fig. 8, in the ground, in which the junction of the service line is safeguarded by the insertion of a solid fuse. The outer pit is made of a depth to suit the position of the casing with its wires. The inner box is made watertight, and is placed inside the pit with air space around it. The bitumen casing projects a few inches inside the inner box, to which it is carefully sealed with bitumen. The upper lid or manhole of the whole street box is set flush with the pavement, and any little moisture that might get in simply drops to the bottom of the pit and filters away.

The method of connecting the feeders to the mains is simple and ingenious. It is the same in both systems, and will be described in our next article on the Callender solid system.



POST OFFICE INSTALLATION. FIG. 2.—Single Pole Dynamo Switch. ¼ Full Size.

THE POST OFFICE INSTALLATION.

We give on these and following pages various illustrations of apparatus connected with this installation. Further illustrations and a full description of the plant will appear in a future number.

Fig. 1 shows the details of the engine-room switchboard ⅛ full size, details ¼ full size.

Fig. 2 shows a single pole dynamo switch ¼ full size.

Fig. 3 is a plan of the distributing switchboard—ground floor.

Fig. 4 shows details of same.

The plan is one-eighth full size, and the details are half full size.

ELECTRIC MINING MACHINERY.*

BY LLEWELYN B. AND CLAUDE W. ATKINSON, A.MM.I.C.E

During the last four years the authors had been constantly connected with the application of electricity to mining, and had spent a considerable amount of time underground, both in experimental work and in teaching those who would have charge of the electrical machinery. It was pointed out in what way the conditions of mining work differed from those existing in other industries, and how they had been dealt with, and some of the machinery now actually employed was described.

The use of compressed air was then discussed, and the results of experiments were given, showing that the efficiency of this method of transmitting power was 45·8 per cent. for an air pressure of 19lb. per square inch, decreasing to 25·8 per cent. for an air pressure of 40lb. From more recent experiments by Prof. Kennedy, F.R.S., M.Inst.C.E., it was found that in practice an efficiency of 31 per cent. might be realised, or 45 per cent. if the air was heated before being passed into the motor. In the case of the electrical transmission of energy, except when distributed into very small units, there was little difficulty in obtaining 50 per cent. of the power expended in the engine, and there were cases in which an efficiency of 75 per cent. had been realised.

One of the most important points with regard to the employment of electricity in coal mines was whether a motor would be likely to cause an explosion. It was necessary in the case of a machine which perhaps might have to work for several hours without attention to guard against the possible accumulation of an explosive atmosphere around the brushes. For this purpose the authors had enclosed either the whole armature or the commutator only in a practically air-tight casing, and the method had been successfully applied to a motor of 40 h.p. The temperature had been kept down to 70deg. F. above that of the atmosphere by allowing a sufficiently large cooling surface—namely, 2·3 square inches per watt. To meet the objection that if the fire-damp should leak into these covers the resulting explosion might be as disastrous as if they did not exist, it was pointed out that whenever the proportion of marsh-gas to air exceeded 3 or 4 per cent., combustion would take place quietly, and the resulting carbonic acid would tend to prevent explosion in the case of farther leakage. Moreover, the authors proposed, in special cases, to introduce a constant supply of carbon dioxide from a steel cylinder into the interior of the casing, thus preventing the ingress of an explosive mixture. Similar methods were adopted for enclosing the switches, and sparking was prevented by providing a resistance coil of small self-induction, which was always connected to the ends of the magnetising coil so as to form a path through which the current in the latter might continue even when the main circuit was broken. The switch itself also had a resistance coil connected to the several points with which it made contact, so that by slowly opening the circuit sparking was practically done away with.

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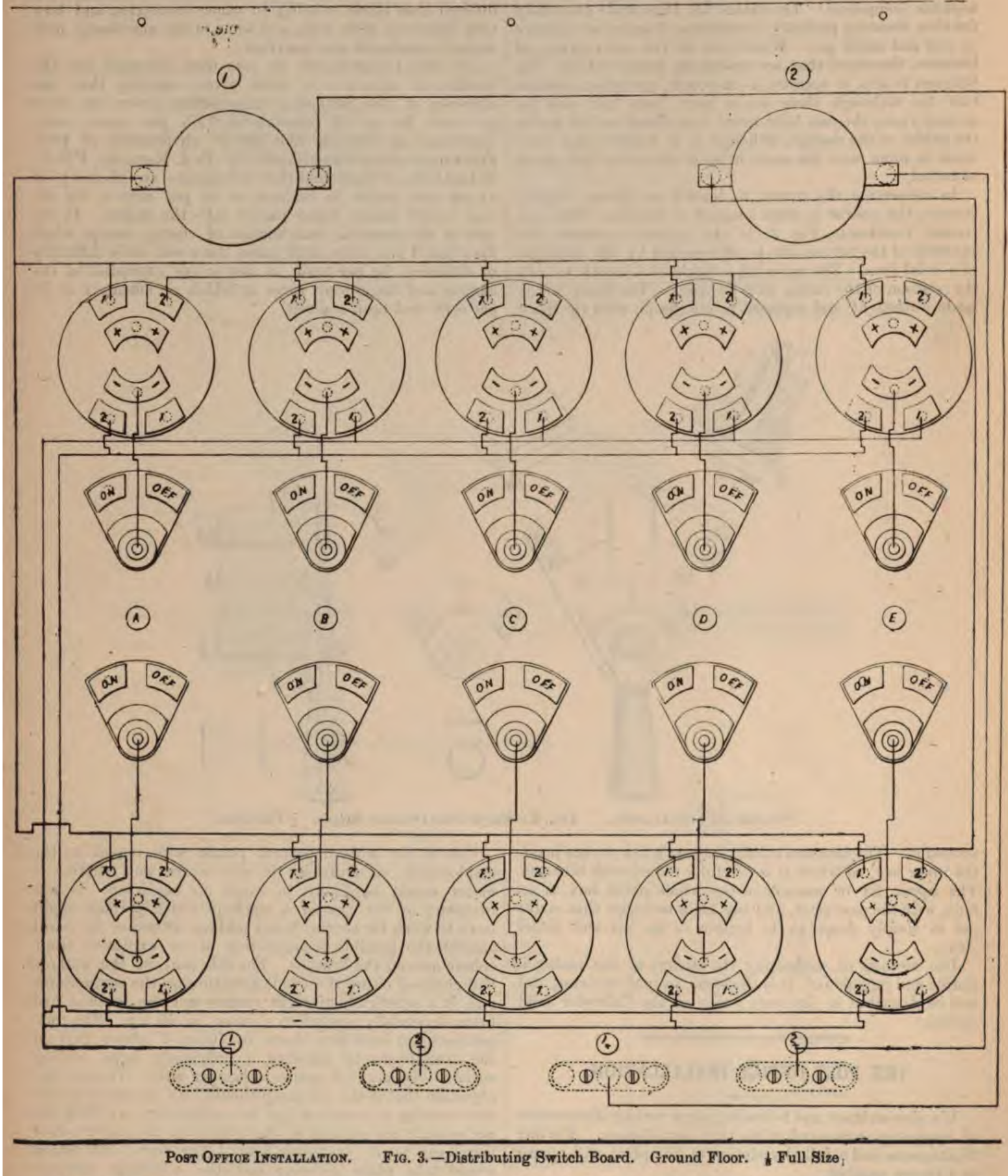
* Abstract from paper read before the Institution of Civil Engineers.



Post Office Installation. Fig. 3.—Distributing Switch Board. Ground Floor. ¼ Full Size.

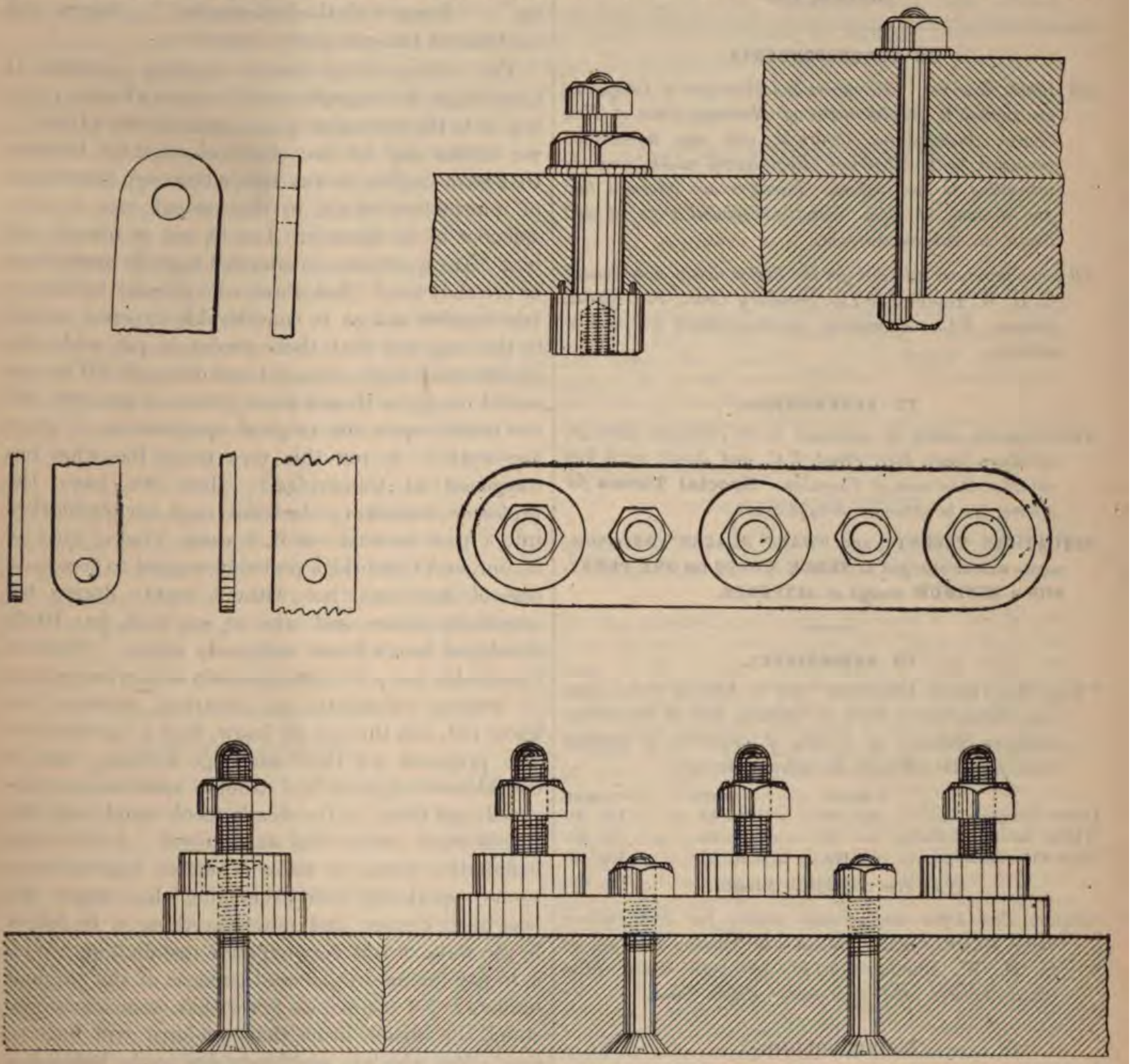
The application of electricity to pumping in mines was then described and illustrated. The use of belts for driving was not recommended on account of the want of space and the difficulty of keeping them in good condition in dirty and wet situations.

The employment of electric power for actuating coal-cutting machinery was suggested in 1873 by Mr. Henry Wilde, and first practically applied by Mr. F. Mori, in 1887, whose machine was illustrated. It had a cutter of the bar type, revolving upon its axis, and was driven by a dynamo having a normal output of 10 h.p., situated at a distance of about a mile. It was built by Messrs. W. T. Goolden and Co. Their next machine was one in which the armature shaft itself was made to carry the cutter-bar. Later developments of these electrical coal-cutters were given. The proper form and dimensions of the cutters were then discussed at some length, the authors preferring the bar type to that in which the tools were fixed into the periphery of a disc, not only as being less liable to be held fast by a fall of coal, but as cutting to a much greater depth. The cutter-bar ran at the rate of 500 revolutions per minute, and on an average, including stoppages, from 20 to 30 square yards per hour might be cut in fairly hard coal. At Lord St. Oswald's colliery at Nostell, 55 yards were bared to an average depth of 3ft. 8in. in 75 minutes. The relative cost of cutting coal in this way and by hand showed a difference in favour of the machine of 1s. 6d. per ton.

An electric boring machine was described, and also an arrangement for driving an Ingersoll percussive rock-drill by electricity, as well as a special form of dynamo adapted for use in transmitting power for electric mining work, with a high voltage.

The authors arrived at the following conclusions :

(A.) That electric power was destined to become an important factor in mining mechanics, on account of—1. The facility with which it could be used with machines which required to be moved from time to time. 2. The great economy in first cost and reduced cost of working owing to its efficiency being higher than that of compressed air or any other medium of power transmission. 3. The smaller cost of maintaining the cables, as compared with piping, on shifting floors in roadways, etc.



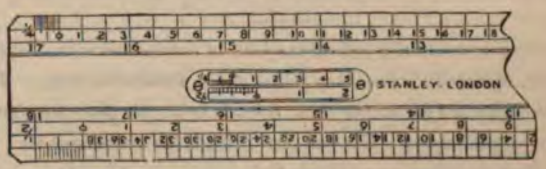
Post Office Installation. Fig. 4.—Distributing Switch Board. Ground Floor. Details ½ Full Size.

(B.) That the methods described were sufficient to obviate all objections to the use of electric motors in coal mining, whether by excluding inflammable gases, or by constructions which would allow of their safe combustion.

(C.) That the experiments, trials, and practical work, extending over four years, showed that—1. Electrical pumps might be used with advantage and economy for mine draining. 2. Electrical coal-cutters could replace hand labour, with saving in cost, and increased production of coal. 3. Electrical drilling machines were available in place of machinery worked by hand or compressed air.

A NEW SCALE.

Mr. W. F. Stanley has introduced an improvement in draughtsmen's scales. We all know how quickly ordinary scales wear out at the points where mostly used. In order to avoid this, Mr. Stanley has introduced a new scale of the first divisions of the scale, by a duplicate in brass of this part of the scale. If this duplicate scale is always used for setting off small dimensions with the divider, it will enable such to be done conveniently, the working edge being thereby preserved for larger dimensions. Another advantage connected with the small brass scale is, that it permits the bows to be set on it without injury, even the ink bow when charged with ink.



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Specimen copies of the paper will be sent on request.

CAMBRIDGE AND DUBLIN.

In the time of the Civil War, the Roundheads, so far as history can be trusted, used to give themselves and their companions some peculiar names. A similar fashion ought to be in vogue now, in order that appropriate cognomens might be given to so-called consulting electrical engineers. Several of these gentlemen would grace the name of "Never-have-a-mind-of-your-own," "Wait-to-see-what-turns-up," "Jump-with-the-last-speaker"; names not euphonious but eminently suggestive.

The history of the electric lighting proposals at Cambridge, for example, would ensure a knotty problem as to the most appropriate name for the adviser—we cannot say for the electrical engineer, because that term implies, at any rate, a thorough knowledge of information which, in the present case, is conspicuous by its absence. Let us get at once to our text. Are specifications intended to guide contractors or are they not? Are those who prepare tenders to take trouble and go to considerable expense, to find in the long run that their tender is put aside, the specification being changed and changed, till no one would recognise it, and some person or firm who did not tender upon the original specification is given the work? Is not this very much like what has happened at Cambridge? Here we have the professor-consulting-electrical-engineer pitchforked into a post because—well, because kissing goes by favour, and Cambridge probably wanted to recognise one of her sons, not without repute during his university career, and who, at any rate, has lately developed into a fluent and ready writer. Whether Cambridge has solved the question as to what volume of writing constitutes an electrical engineer, we know not, but this we do know, that a specification was prepared for the Cambridge lighting, that at considerable expense and trouble tenders were prepared, and then, lo, the weathercock mind finds the specification needs vital amendment. A visit to an installation seems to make a sudden impression as to its superiority over everything else—hence the post haste change, and now everything is to follow in the wake of this very superior installation. Who is to pay for the trouble and expense of the original tenders? Of course, we know that, as matters now stand, the various firms that tendered will have to bear a loss which is absolutely due to the indecision or to the ignorance of the man who framed the original specification. There is no need to beat about the bush, or to say words that will bear two meanings. We most distinctly wish to convey the idea that an engineer who permits this sort of thing is incompetent, and should not be entrusted with work that requires special knowledge and skill. A specification when made public, and upon which tenders are asked, should not require modification, or only in minor details that will not affect a tender or put it out of court. We do not expect a Baker, or a Mansergh, to issue specifications that delude contractors, and an electrical engineer's work is not so difficult as theirs. We should expect an engineer of

Max am Ende's attainments to repudiate with scorn a suggestion that a well-considered specification, say, for a gallery or an ordinary bridge, would require total alteration, because its author had seen or heard of another gallery or bridge. It is the duty of the consulting engineer to know what has been done in particular directions before he issues his specification, and not find out afterwards that he has issued it in ignorance.

A man may be a fluent speaker, a facile writer, and a capable teacher, and at the same time an incompetent engineer. As a rule, professors do not make the most competent practical men. They are imbued with the value of theoretic perfection, and cannot shake off the feeling that what they do must be perfect—that is, theoretically perfect. They cannot understand that theoretic perfection and practical usefulness are often as wide as the poles asunder. When a professor can throw aside this peculiarity he can, and does often, make a competent engineer, but when he does a little at teaching and a little at engineering, he is like a fish out of water, incapable of showing his true natural powers. The true course to pursue is to stick to one thing or the other, and not attempt the *rôle* of Jack-of-all-trades.

There is another problem underlying this question of specifications, and that is connected with wheels within wheels. It is frequently intended that the work shall go in a certain direction, and wire-pulling extraordinary takes place behind the scenes. The delay and discussions at Dublin lead us to believe that something of this kind may be contemplated there, otherwise it surely cannot have required day after day and week after week to decide as to the firm which is to have the contract.

LONDON LIGHTING.

On Tuesday last the formal commencement of the work in connection with the City lighting took place, the Lord Mayor laying what may be termed the foundation stone—this being a stone at the grand junction. We understand that the whole system will be carried out as one enterprise, and that the generating stations will, so to speak, be interchangeable. This is as it should be, as instead of divers interests there will be but one interest to command—the syndicate under which the work is done. With the Thomson-Houston apparatus on the one side and the Brush on the 'other, there is little fear of trouble. Both firms have carried out excellent work, and the development of each has shown keen commercial perception acting as guide onwards and upwards. According to our information, the Callender system of underground mains is to be used, and here, again, we come to a firm that has had considerable experience with work in the streets of London. Altogether the outlook is favourable, and still more so if we consider what an impetus will be given to the manufacture of all electrical accessories. Taking the most moderate estimates, the outlay upon wiring and fittings must reach to at least six figures within the next few months, and this work will be distributed among a large number of firms. The street lighting, as we have so often pointed out, is but a commencement of the work, and the part that will ultimately be least appreciated. It is the interior lighting that is the main object, and the one that will prove most advantageous to the combined syndicate and to the public. Before, however, we can have interior lighting the authorities must necessarily permit the breaking up of streets. And as the lighting by gas has long been voted bad, the authorities decided that the very best course they could take would be to arrange first for the proper illumination of the streets of the metropolis of the world.

CORRESPONDENCE.

"A NEW INSTRUMENT HAS BEEN INVENTED."

To the Editor of the Electrical Engineer.

Sir,—So you say in a paragraph, page 108, of your last issue, where reference is made to Mr. Reginald Jones's "very simple little piece of automatic apparatus"; but on page 126, in Mr. Bromley Holmes's paper, I find something of the same sort described as "a special apparatus devised by the author for this purpose"—viz., making continuous tests of insulation resistance.

Fancy your forgetting Edison's red and green lamps of years ago!—Yours, etc., Wm. H. Massey.

25, Queen Anne's Gate, Westminster, 3rd Feb., 1891.

INAUGURATION OF THE WORK OF THE ELECTRIC LIGHTING OF THE CITY OF LONDON.

The first practical step in what has been so long delayed and so anxiously looked forward to—the public electric lighting of the City of London—took place with due ceremony on Tuesday afternoon, when the Lord Mayor placed in position the first stone of the grand junction-box of the two systems which together are to supply electricity to the whole of the City. The place of this junction-box is in Walbrook, close under the walls of the Mansion House.

It is well enough known to our readers that the whole extent of the City has been divided into three districts. The contracts for two of these (the central and western divisions) have been obtained by the Brush Electrical Engineering Company, comprising a little over half the total area, and for the other (that east of the Mansion House) by the Laing, Wharton, and Down Construction Syndicate. Contracts on so large a scale were felt beyond the powers of the electrical companies without further capital, and at first it was proposed to promote different companies for the two concessions. The wiser course has, however, been taken of amalgamating the two proposed companies into one, so as to obtain the double advantages of direction from one central office, and of having a junction between the two systems of distribution in case of accident or need of aid by either of them. A pioneer company has therefore been formed under the title of the City of London Pioneer Electric Lighting Company, with, it is understood, the powerful backing of the Rothschilds and the Lord Mayor, with an extremely strong board of directors, including the Duke of Marlborough and the Earl of Suffolk and Berkshire, together with certain of the directors of the two contracting companies. When this company has carried out the definite contracts now entered into with the Commissioners of Sewers, and has works in going order, the large work necessary for the private lighting of the whole of the City will be undertaken, the large company having definite concessions and plant and works, will be able to go to the public for the necessary capital. It is this company's junction-box of happy omen that the Lord Mayor was called upon to inaugurate.

Pushing through the crowd of spectators which had congregated out of Cheapside in Walbrook, kept in place by a cordon of police, a large group composed of electrical and financial leaders, with the members of the Honourable Commissioners of Sewers and the City officials were seen peering into a large hole in the ground, decorated with crimson cloth and surmounted by a small derrick. This was the situation of the junction-box, in which large casings of Callender bitumen for the mains ended, and lined inside with white brick, while swinging from the derrick, ready to be laid, was the first stone, with the inscription :

THIS STONE WAS LAID BY
THE RIGHT HONOURABLE ALDERMAN JOSEPH SAVORY
LORD MAYOR
ASSISTED BY MR. DEPUTY FRANK GREEN
CHAIRMAN, AND THE MEMBERS
OF THE HONOURABLE COMMISSIONERS OF SEWERS
IN COMMEMORATION OF THE COMMENCEMENT
OF THE WORK OF LIGHTING
THE CITY OF LONDON BY ELECTRICITY
3RD FEBRUARY 1891 A.D.

Contractors :
The Brush Electrical Engineering Company, Limited.
The Laing, Wharton, and Down Construction Syndicate, Limited.

The Lord Mayor, who attended in his scarlet robes of office, having inspected the work, the Chairman of the Commissioners of Sewers introduced Lord Thurlow, P.C., F.R.S., the chairman, the Duke of Marlborough, and the other directors of the Brush Company, and Colonel Martindale, R.E., C.B., chairman, and the other directors of the Laing, Wharton, and Down Syndicate. The Lord Mayor pulled the cord and released the stone, which fell with a dull thud into its place—rather suggestive, in fact, of a graveyard ceremony—and declared the stone to be well and truly laid.

Mr. Deputy FRANK GREEN, in asking the Lord Mayor thus to inaugurate the first practical step in the lighting of the City of London, pointed out the immense importance of the character of the work they were now beginning. It was in March, 1878, that the question of lighting was first referred to the Streets Committee of the Commissioners of Sewers, and since that time no less than 39 reports had been sent in for the consideration of the Commissioners. This he mentioned as showing that the authorities had given no meagre attention to the interests of the ratepayers of London. One name he would like to mention, that of Mr. Pannell, as one of the most strenuous in constant endeavour to bring the question of the electric lighting of the City to a successful issue. Much also was due to the contractors for their liberal views in meeting the wishes of the Commissioners. They were now within measurable distance of the time when London should be the best lighted city in the world, as it was the best scavenged. He would like to take the opportunity of recognising the zeal, energy and ability of the officials and engineers of both companies, and of the solicitor, Mr. Bates, whose work in passing the Bills had been considerable. The wishes of the Commissioners were to obtain the best for the City, whose streets were under their charge, that was possible to be achieved.

The LORD MAYOR said it gave him peculiar pleasure to be the motive power to lay the first stone of the City of London Electric Light Works in its place. It had often been said that London was backward in introducing the electric light in its streets, but he considered it had done well to wait and take the advantage of experience, so as to be certain when it was done to have a good and thorough system. He looked upon the present step not as a revolution, but an inauguration of immense improvement ; and the union of the companies which are to carry out the work was well symbolised by the chamber of union erected in such happy proximity to the Mansion House. He felt great satisfaction that the inauguration of such an important step had taken place during his period of office, and congratulated Mr. Deputy Green upon the happy termination of the labours of the Commissioners of Sewers. He hoped it might be possible for them to do as much for the dispersion of fog by electricity in the future.

Lord THURLOW thanked the Lord Mayor, and handed, in memento of the occasion, an inkstand formed of silver-mounted specimens of the cables to be used in the mains.

Colonel MARTINDALE presented a similar memento to the Chairman of the Commissioners of Sewers.

The visitors invited to the ceremony then trooped off to Cannon-street Hotel, where an elaborate luncheon was served, the Lord Mayor, owing to a previous engagement, being unable to attend, and Lord Thurlow took the chair.

Colonel MARTINDALE, in proposing the toast of "The Honourable Commissioners of Sewers," alluded to the incessant work of this body in bettering and widening the streets, and said it was owing to the exhaustive enquiries which they had made, together with the best scientific intellects of the land, amongst them Mr. W. H. Preece, chief engineer to the Post Office, that they had been able to obtain the best installation of electric light in England.

Mr. Deputy FRANK GREEN, in responding, said that one of the greatest difficulties in the question of electric light, or any other improvement, was the consideration of the interests of the ratepayers. They had to steer between the legitimate demand of the public and the calls on the pockets of those who pay the cost. They had held their hands until a system as nearly perfect as possible had been presented to them. It must not be forgotten that some years ago street lighting was tried as an experiment. This experiment cost them £8,000, so that it would be seen that even at that time they were desirous of lighting the City by electricity. Since then electric science had advanced with giant strides, and now that the system had been decided upon the contractors need not fear that any obstacle would be placed in the way of co-operation.

The DUKE OF MARLBOROUGH said it gave him great pleasure in proposing success to "The Electric Lighting of the City of London." For many years he had been connected personally with electric lighting, both in this country and in America, and he was greatly pleased to be now connected with a system of such large potentiality. In the City of London was congregated the greatest wealth the world possesses, and to light successfully the enormous number of houses in its area demanded the utmost consideration. The fact that London was liable to suffer from periods of darkness in the daytime threw greater strain upon such an undertaking than in any other city. The remarks as to caution he considered most opportune. He remembered going with several gentlemen, with the late Mr. Ladd, to see the first Brush arc lamp exhibited in England, which was run on the site of the Grecian Theatre. He might say with great prudence, that owing to the careful deliberations of the progress since that time, that the present undertaking was going to be a thorough success. For one thing, the present scheme was not too ambitious, and they were not in a position as to be not quite certain as to what they could or could not carry out. The only thing to be feared was the narrowness of the streets in some places, where there might be some difficulty in avoiding gas and other pipes, but from what he had heard from the engineers this would not be insurmountable. When the work of the Pioneer Company, over which the Lord Mayor has consented to preside, has been concluded, he thought there would be no difficulty in asking for the money for a complete system. He was glad the work had been able to be placed in the hands of a single company. In this their action was opposed to that of the Board of Trade, who encouraged two companies and two sets of mains in the same district. It was his opinion that this must result in loss both ways, either by fighting and loss to the shareholders, or in amalgamation, in which case double the necessary mains would have been laid. In their case they had carefully calculated the extent of the demand, and arranged their mains accordingly. When finished he thought they would be in possession of a more successful system than any other yet undertaken.

Mr. PREECE, in responding, said he felt within measurable distance of the fulfilment of the wishes of his life—the lighting of the City of London by electric light. He had other wishes which had not seen so successful an issue. Instead of castles in the air, this might be said to be a castle in the ground. When he had taken part in that funereal ceremony they had attended that afternoon, he thought as he saw therein the products of General Webber's inventions:

> "Not in ohms nor in volts they wound him;
> But he lay like a warrior taking his rest,
> With his bitumen casing around him."

One of the things they had paid most attention to in designing the system of supply was that of safety. He could confidently say that not one point had been neglected in the system of lighting the City to provide for the greatest possible safety. It had been mentioned that £8,000 had been spent already in electric lighting in the City. It was nearer £12,000. Indeed, he could say that up to the present time there was no corporation that had actually spent so much money in electric lighting as the Corporation of London. Since their first experiments the first cost of the plant had become nine times cheaper. The cost of manufacturing electricity was now cheaper than that of manufacturing gas. It was not so cheap to distribute. This was owing to the sale of waste products, but there were towns in America where they are not able to utilise their waste products, where the manufacture and distribution of electricity is actually cheaper than that of gas. He had visited all the principal towns yet lighted by electricity —Chicago and New York and Boston, Rome, Milan, and Paris—yet he could truly say that when the contracts were carried out the City of London would be the best-lighted city in the world. He hoped in times of celebration they would put up the motto "The light of other days has faded."

The health of the contracting firms was then given.

The following are the official particulars given of the contracts:

The streets will be lighted in all by 400 arc lamps of 2,000 nominal candle-power, and 1,000 incandescent lamps of varying candle-power, absorbing from 100 to 200 watts per lamp, while the arcs are to be 10-ampere lamps, absorbing 500 watts each.

The provisional orders granted to the above-mentioned two companies contain many special features, and under the contracts entered into with the Commissioners of Sewers the companies will light every street, lane, court, and alley, and will obtain what is practically a monopoly of private supply.

The cost to the City of London for the illumination of the whole of its streets by electricity will, when fully completed, not very much exceed £20,000 per annum, and for this the Commissioners will have probably 20 times the illuminating power at present obtained from gas.

The contracts with the Commissioners require that the works for public lighting shall be commenced before February 19 this year, and the ceremony to-day consists in starting the underground works, by constructing the main junction-box to be used for connecting the mains of the two contractors, the object being to make their systems interdependent, so that in the event of a serious accident occurring at either of the generating stations, current will be obtainable from the other station.

The site of the Brush generating station is on the south side of the Thames, and the mains will cross to the City over Southwark and Blackfriars bridges. The station will ultimately have a capacity of 600 2,000-c.p. arc lamps and 60,000 60-watt incandescent lamps, this being for the supply of the central division.

The generating station for the eastern division will be situated on the banks of the river between the Custom House and the Tower of London, and the Laing, Wharton, and Down Construction Syndicate have designed the plant to have an ultimate capacity of 600 2,000-c.p. 10-ampere arc lamps, and 120,000 35-watt incandescent lamps.

The systems to be employed by the contractors are already well known. The Brush Company will employ their well-known Brush apparatus for street lighting, and the Mordey-Victoria alternating-current dynamos and transformers for private lighting.

The Laing, Wharton, and Down Construction Syndicate will employ their well-known Thomson-Houston apparatus, both arc machines and lamps, for public lighting, and alternating-current apparatus for private lighting.

The systems of both contractors have already been extensively employed in America for many years, as also on the Continent, and since the amendment of the Electric Lighting Act of 1888, in this country.

LITHANODE ACCUMULATORS.

Lithanode is a term invented by Mr. Desmond FitzGerald to fit the discovery made by him of a method of moulding secondary battery plates out of litharge in slabs as solid as stone (Greek *lithos*, a stone)—stone anode—or, shortly, lithanode.

The name is sufficiently familiar to electrical engineers who have given some attention to Mr. FitzGerald's invention, the new type of cell having been brought forward some few years ago by the Union Electrical Company, whose operations were, however—owing to financial rather than electrical reasons—brought to a conclusion, and the invention was taken over by the Mining and General Electric Lamp Company.

This company has been busy perfecting an electric portable miner's lamp of about the same weight as an ordinary safety-lamp, and in making elaborate experiments with and tests of the lithanode battery, in conjunction with Dr. Frankland, F.R.S., who is one of the directors, and under the immediate supervision of Mr. FitzGerald, who is consulting electrician to the company. Many practical details of the construction of the miner's lamp have been worked out by the manager, Mr. Moscrop, and valuable aid in the proper proportioning of the constituents of the batteries has been given by the electrical engineer in charge, Mr. Hough, who was formerly with Sir F. Bolton.

Arrangements have now been made for the manufacture, on a practical scale, both of the light portable miner's lamp and also of an ordinary type of secondary cells for stationary and traction use very much lighter in weight for the capacity than any now made. The miners' lamps have been on exhibition this week at a mining exhibition organised at the Institution of Civil Engineers. The larger types of lithanode cells are being fitted to a private launch, and are being supplied for lighting purposes to several private installations. It may, therefore, be interesting to present our readers with as full particulars as are obtainable of this invention, which is one, we may remark, that certainly seems to promise a very extensive revolution in secondary battery manufacture.

The ordinary manufacture of accumulators, as at present achieved, is done upon engineering principles and for engineers. The users of secondary batteries in electric light installations are content, in most instances, if a practical storage of electrical energy is rendered possible with a fair workable return in output, and the weight is not of absolute first importance. In traction work the case is altered, and weight as compared with capacity is a necessary consideration. Much more is this the case in portable batteries for such articles as miners' electric hand lamps.

The usual type of accumulator has, when applied to delicate work, the following disadvantages:

1. Local action is unavoidable between the lead support and the peroxide of lead, the peroxide being converted into sulphate of lead, and the lead support also running down into sulphate. In large batteries, though this is a disadvantage, it is relatively far more so in small ones.

2. There is often no just proportion in the ratios of the various constituents of the battery.

3. The battery as a whole is unnecessarily heavy. The manufacturer of large cells detests all niggling, delicate work, and does not aim at perfection, and a compromise is accepted in practice.

In portable batteries, and in batteries for traction purposes, the weight is required to be reduced as much as possible, and careful attention to everything that can conduce thereto is very necessary. To achieve this, the weight of the elements and the weight of the electrolyte must be reduced as much as possible. To obtain the best result, the three elements, anode, cathode, and electrolyte, must be accurately proportioned to the chemical reactions. There must be no excess of peroxide, but little of spongy lead, and little or none of the electrolyte.

The lead supports which are necessary to afford a conducting frame to the peroxide occasion much of the excessive weight of secondary cells. For some inscrutable reason it has always been assumed by makers of secondary batteries, and Mr. FitzGerald himself had long been under the same impression, that for the cathode also lead was practically the only material that could be used as the support to avoid chemical reaction. For the peroxide plate it certainly is the only support available except platinum or iridium, both impossible in practice on account of their excessive cost. But for the spongy lead there are several other conductors which might advantageously replace lead with much less weight. One such conductor has been found in copper, which is preferably coated with lead. In the new cells made by the Mining Electric Lamp Company under FitzGerald's patents, the support for the spongy lead plate is formed of a double network of copper gauze dipped in lead, upon which the active material is compressed in a solid block, affording a perfect support, and the total weight of the spongy lead plate is reduced in the proportion of 3lb. 10oz. to 7lb.—*i.e.*, is hardly more than 50 per cent. of the ordinary plate. In a complete cell, the glass containing cell, electrolyte, and peroxide plate being of the same weight as before, this improvement alone gives a gain of 15 to 20 per cent. in the total weight of the cell.

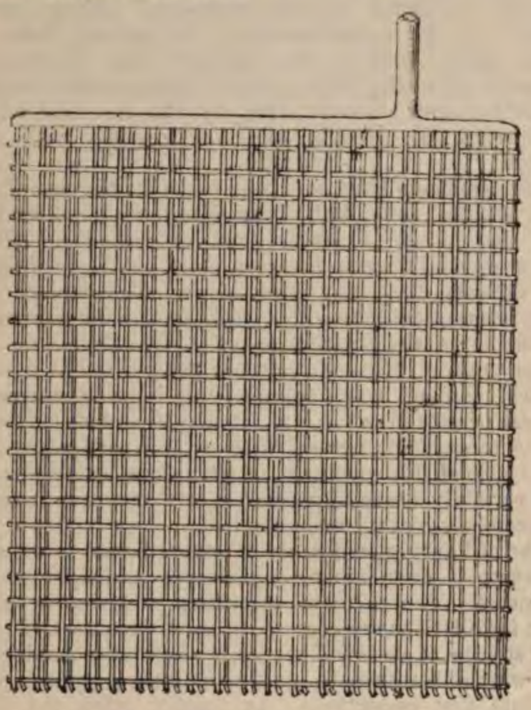

FIG. 1.—**FitzGerald's Copper Frame for Spongy Lead Plates.**

We have not yet spoken of the essential and major invention of Mr. FitzGerald, the formation of the lithanode plates.

The attempt has been several times made to form the peroxide plates out of compressed litharge, or even out of compressed peroxide of lead. The difficulty that has stood in the way of practical manufacture has been that these plates of compressed material would not keep their consistency, but eventually fell to pieces and crumbled away when placed in water or in an acid electrolyte. Dr. Frankland's process was an improvement, inasmuch as it introduced a chemical action, the plates being made by mixing litharge with sulphuric acid and then moulding it into blocks under compression. In this method the chemical action is too sudden and the result not perfect.

Mr. FitzGerald's lithanode is produced from a mixture of litharge with certain other chemicals, in which the chemical action is very gradual, giving the particles time to range themselves, and the resultant material is very homogeneous and becomes a hard and solid block.

In the process of manufacture the litharge and other chemicals are weighed out and mixed with solution into a paste, and transferred immediately before it has time to set (which it at once commences to do) to a die-plate of the form of the element required. This is placed under an hydraulic press and subjected to a pressure equal to that of 1½ tons per square inch. These plates or blocks are then placed in racks to dry and gradually consolidate. They are usually left thus to season for a fortnight, but can be used in two or three days if need be.

The next process is termed "browning." They are subjected to a special preparation, which coats them with a superficial skin of peroxide. If placed without this preliminary process in the forming bath the peroxide would begin to form in spots, and it would be very long before the whole material was attacked and converted to peroxide. Whereas, after being "browned," action takes place all over the surface, and the conversion goes on regularly till the whole plate is changed into peroxide of lead. Formerly, this process used to take a fortnight to accomplish, but by improved methods is now brought about in four or five days. The proportion of peroxide in the lithanode plates has varied—not all of the substance is converted into pure peroxide. There is always a little sulphate, but in the present process over 90 per cent. is converted. It would, no doubt, be possible, though difficult, to overcharge the lithanode and convert the whole into peroxide, but this, even if done, would decrease its hardness while increasing its fragility. A slight amount of sulphate seems to be necessary to ensure strength of plate.

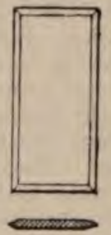

FIG. 2. Lithanode Slab.

For the small plates of the miners' lamps these lithanode blocks or plates are very closely attached to a strip of platinum foil. Three ebonite screws are inserted in the body of the plate, and the platinum foil, backed by a strip of ebonite, is tightly screwed by ebonite screws to the back surface of the lithanode. A lead plug connected to the platinum serves as terminal. The spongy lead of the miner's cell is supported, as explained above, upon a network of copper. The result is that the lithanode secondary cell is somewhere about 50 per cent. less weight for the output than any type of paste and grid cell at present made.

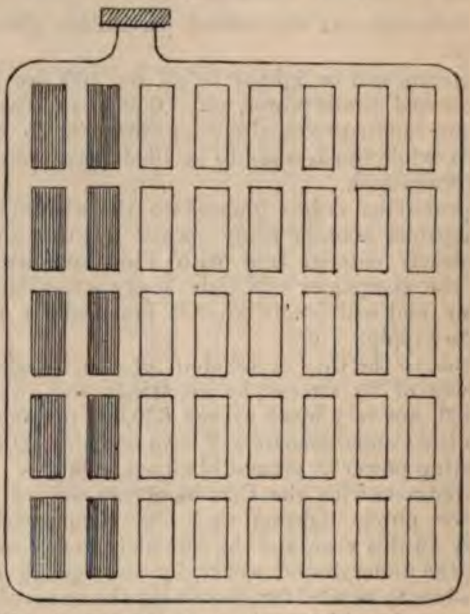

FIG. 3.—FitzGerald-Frankland Lithanode Plate.

The mining lamp is now being made in considerable quantities. It is an entirely practical lamp made for the hands of miners, and embodies many little points of detail carefully worked out from the point of view of ease and cheapness of manufacture and resistance to rough usage. The principal thing to notice in the lamp, as distinct from the cell, is the outer casing, which is of thin steel surrounding the cell and leaving a slight air space all round the cell, being kept in place by indiarubber knobs inside. This arrangement gives a cheap and exceedingly effective protection to the lamp, any accidental knocks being received on the elastic surface of the steel casing without destroying the cell. The lamp is an ordinary small Edison-Swan lamp mounted with a projecting cover of toughened glass. The weight of the lamp is 3lb. 4oz., burning for 12 hours, and gives the light as of 1½ to 1 of the latest type of Muesler lamp, the Marsaut improvement. It is almost exactly the same weight as this lamp, or even a little less. A larger type of lamp gives double the light of the miner's lamp and weighs 4lb. It is intended for use in ships' holds, gas works, and other places where a stronger light is required and the extra weight is no objection.

The larger cells which the company are manufacturing for stationary work are, in fact, a combination of the lithanode and the copper-net framework plates, with the method of casting grids patented by Dr. Frankland. The lithanode blocks are moulded and pressed in large plates like chocolate cakes, and broken up afterwards into pieces of the shape shown, with bevelled edges. The pieces, after they are partly "formed," are placed in a mould and the lead grid cast around them, giving a battery plate of the shape indicated in the illustration.

The plates are alternated in the complete cell with thin plates of lithanode material compressed on the copper net.

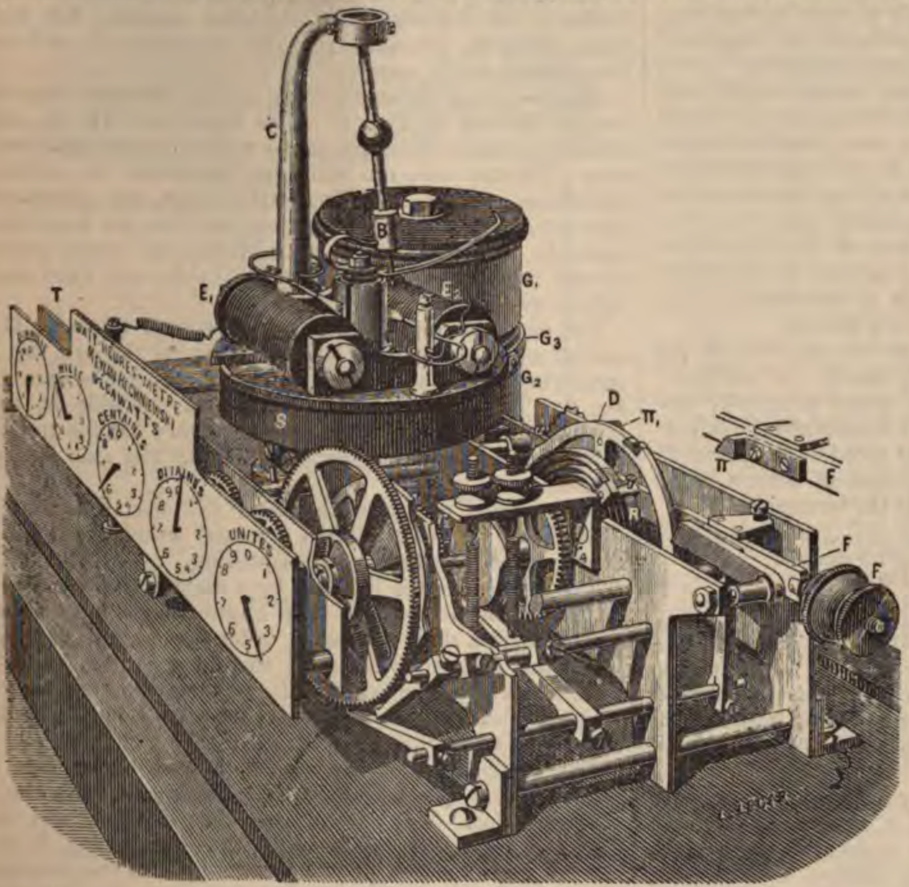

Fig. 1.—Meylan-Rechniewski Electric Meter.—General View.

The cells have been tested continually by Dr. Frankland, and the results show, for instance, in an ordinary size cell a diminution in weight of 15 to 20 per cent. Thus the ordinary E.P.S. L type, weighing 75lb., gives 120 ampere-hours. The new Lithanode-Frankland cell yields 200 ampere-hours for a weight of 73lb.

The works of the Mining and General Electric Lamp Company comprise a 18-h.p. semi-portable Wallis-Steevens steam engine, driving through countershafting low-pressure dynamos for charging. The principal dynamo is a Crompton machine capable of giving 950 amperes at 12 volts, though it is not generally used over 750 amperes. A second Crompton dynamo, giving 450 amperes at six volts, is also used, and an Elwell-Parker dynamo, giving 250 amperes at six volts, is used on the acid baths. On the same floor are fitting-shops, and a long room for charging and converting the plates. Above is the laboratory, and testing-room, and moulders' room, with dies and hydraulic presses. Another building has just been erected for the manufacture of the larger cells. The company seem to be laying themselves out for practical supply of lithanode plates, and we shall be greatly interested in the future of these batteries.

THE MEYLAN-RECHNIEWSKI ELECTRIC ENERGY METER.*

BY E. MEYLAN.

(*Concluded from page* 121).

We hope to obtain better results by using a more robust piece of machinery in the shape of a Gramme motor, which gives no sparks and has no dead point. To adapt it entirely to our needs it is sufficient to add two arrangements—one destined to make the starting certain, the other to regulate the speed.

A motor taking a constant current, supplying the very variable work necessary to take the readings and giving at the same time the time factor, has, furthermore, the advantage, by no means negligible, of being able to be inserted directly in the shunt circuit, which is needed for the wattmeter, so that in this way one shunt circuit is all that is required.

We have indicated the motives which have guided us in the choice of the two principal parts of our meter; it remains to discuss the arrangement for registering and integrating the readings. But here we are not dealing with general principles; all that can be said is that the arrangement must be as simple as possible. We shall indicate this mechanism in the detailed description of our instrument, to which we now pass.

The Meylan-Rechniewski meter, of which Fig. 1 gives a general view, comprises six principal parts:

1. An electric motor, M, Fig. 2, with permanent current and constant speed.

2. A train of wheels, reducing the speed of the motor and communicating to a final or principal axle, A, Fig. 3, a strictly uniform and continuous rotation, of which the speed is one-third revolution per minute.

3. An electro-dynamic balance—a wattmeter formed by one or two fixed coils, G_1 G_2, traversed by the main current, and a movable coil, G_3, fixed to a beam, F, mounted upon a pivot or upon knife-edges; this balance gives rise, under the action of the main current and the shunt current, to a force proportional to E I, a force which is balanced by a fixed counteracting force.

4. An elastic cam; this is the part of the apparatus which works the readings of the balance.

5. A gearing arrangement controlled by two detents, communicating to the first moving part of the totaliser, T, the movement of the principal axle during the period of each reading of the balance. The action of the detents is dependent upon the movements of the principal axis of the elastic cam.

6. A totaliser, whose various dials show in hecto-watts the consumption of energy in the circuit upon which the meter is connected.

Constant Speed Motor.—The motor which we have at last settled upon is of rather a special type. Fig. 2 gives a section and partial elevation which will serve to make its action clear.

It is a disc motor, but one in which the two field magnet poles are on the same side of the armature, that is to say, above this latter; this arrangement gives rise, as one may see at once, to a real uplifting of the armature core under the action of the magnetic field. This considerably relieves the jewel upon which the pivot rests.

The field magnet system comprises two semi-circular pole-pieces, connected together with two square pieces fastened by two bolts, which form the cores of the two electro-magnets, E_1 E_2, Figs. 1 and 2.

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* Translated from *L'Electricien.*

The armature is a flat ring of iron, insulated and wound with 3,000 turns of fine wire, forming five or six segments, connected to an ordinary commutator. This armature is carried in an ebonite support, mounted upon the axis, V, whose endless screw works the wheels, $r_1 \ . \ . \ . \ r_4$, Figs. 1 and 3.

The field magnet is fixed to the pillar or standard, C, which also carries one of the brushes, $\beta +$. The second brush is held by an insulating support. These brushes are formed by an elastic wire terminated by a flat pinch of silver wire of ·15 or ·2 millimetre diameter.

This arrangement is both simple and easy to put together or take to pieces; all that has to be done is to loosen a screw, draw out the upper part of the standard, and then remove the nut which holds the lower pole-piece fast against its supporting piece.

The armature spindle passes through a socket and guide which forms part of the framework of the mechanism (see Fig. 3).

The system of regulation of which we have spoken consists in periodically shunting the coils of the armature. This result is obtained very simply by connecting one of the commutator plates to the insulated passage which pulls round the conical pendulum which we use as speed indicator. One of the brushes ($\beta +$) being itself connected to the ball of this pendulum, it can be seen that when the ball, B, touches the contact, c, a part of the shunt current passes outside the armature. For instance, when the plate is under $\beta -$, the current goes by way of X, C B, $c \beta -$ to the field magnet, I, without passing through the armature. On the other hand, when this plate is beneath $\beta +$, the shunt current passes entirely into the armature.

On an average, a decrease of about 50 per cent. of the motor energy is thus produced, which is sufficient, generally speaking, to maintain the speed practically constant within fairly large limits. We have taken the following readings of the variations of the speed of the principal axle connected to the motor by a train of wheels, while varying the difference of potential at the terminals :

Difference of potential.	Time of 1 revolution of principal axle.
87 volts.	181·5 seconds.
91 ,,	180·3 ,,
96 ,,	179·3 ,,
100 ,,	178·3 ,,
104 ,,	177·5 ,,

That is, for a variation of 17·7 per cent. of the volts, the variation of speed was only 2·2 per cent.; in the practical limits of electric lighting, even with a total variation of 10 per cent., the maximum possible error under this head would be only about 1·5 per cent.

The sparking at $c \beta$ is absolutely invisible, for it only takes place from the breaking of a circuit traversed by ·025 ampere; moreover, the contact is always perfect; and, lastly, the current is never entirely broken, as is the case in the well-known arrangement of Marcel Deprez. On the other hand, it may be considered as practically constant when care has been taken to give the armature a resistance relatively small compared to that of the whole circuit.

The regulator has yet a further purpose, that of assuring a sharp starting of the motor by giving rise to a strong increase of the shunt current while yet the ball has not quitted its central support. This is brought about by a contact, c^1, connected with the axle of the motor, and consequently with its mass and the wire, f, with the outer extremity of a resistance, X—the other extremity of this resistance being connected to the standard, C. It is seen that so far as concerns the contact between B and c^1, the resistance, X, is shunted, and the shunt circuit then only includes the motor and the rheostat, R_1. The motor therefore rapidly gains its normal speed, and there is never the slightest fear of a misstart.

Here a spark is certainly observable at the breaking of the contact, c^1 B, but this effect in practice only occurring once a day, offers no inconvenience. It is hardly necessary to point out that a reading made at the moment of actual starting would be not correct, but here again this accident is practically negligible.

In the case when it is desired that the meter should act with very variable differences of potential, we employ a *double slotted way*, that is, a passage formed by two parts connected with two plates diametrically opposite.

The ball, B, arrived at the end of its course, becomes interposed between the two contacts in such a way that two plates of the commutator are always at the same potential as one of the brushes.

The diminution of motive power is then double what it is in the previous case, and the regulation is considerably more perfect. The following results were obtained under these conditions :

Volts at terminals.	Period of one revolution of motor.
140 volts.	39·1 hundredths of second.
112 ,,	39·9 ,, ,,
104·5 ,,	39·8 ,, ,,
98 ,,	40 ,, ,,
94 ,,	40·5 ,, ,,
90 ,,	40·5 ,, ,,
86 ,,	41 ,, ,,

From 90 to 140 volts, the variation of speed has therefore been 2·5 per cent. only for a variation of 50 per cent. in the potential.

Clockmakers may find, perhaps, these results not very brilliant; but we think that electrical engineers will find them sufficient, provided they can absolutely depend on the running of the motor.

Electro-dynamic Balance.—This part of the instrument is seen to the left in Fig. 1. The fixed coils, G_1 G_2, are formed by insulated copper strips wound on a central wood core. The two coils are connected sometimes in parallel, sometimes in series, according to the types, but always so that the actions are added together, and that the force acts upwards. The current is taken from two brass blocks pierced with holes, into which the cables are fixed and tightly screwed by a set screw.

The movable part is formed by a roll of fine wire, G_3, carried upon an ebonite support fixed to the arm by a metal ring riveted to this latter. This part can be seen in Fig. 3. The current is led to the coil on one side by the pivots, and on the other by a band of very flexible tinfoil, fixed upon an insulating support near to the axis of suspension.

In the small model of the meter the arm, F, is simply pivoted at $p \ p$; but to obtain a greater sensibility it is advisable to adopt a knife-edge suspension.

The movable coil is balanced by a counterweight screwed to the end of the arm, F. This counterweight must be regulated with a slight excess, in order that even in the case when the electric force is nil there may yet be a certain force to act upon the arm to raise it, this, of course, constituting a false zero, which is taken account of in the registration, as we shall see.

The engagement of the arm, F, by the elastic cam is brought about by a piece of steel, π, fastened to this arm.

Elastic Cam.—The elastic cam, Fig. 3, comprises the disc, D, carrying the steel cam, π_1, the spiral spring, R, the axle, A_1, and a clutch, L, which connects it to the principal axle, A. The axle A_1 is carried directly on the end of A between points or on pivots. While the cam π_1 does not meet the piece π of arm F, the spring R is not twisted, and the shaft A_1 participates in the movement of the axle A.

At the moment of contact, on the contrary, the cam is stopped and the spring is twisted through an angle proportional to the pressure that the arm exercises originally upon its acting end. At the moment when the cam raises the arm the reading is finished.

Friction Gearing and Detent.—The movement being uniform, the sum of the torsions will make the sum of the times of reading. To obtain this it is necessary to couple the axle A with the first wheel of the totaliser, T, during the periods of torsion. For this purpose we have constructed a friction gear, controlled by detents, of which one is set in action by the actual movement of the principal axle, and determines the *true origin of the reading*, while the other is dependent on the movement of a click, and *set in action by the active force of the elastic cam* at the end of the reading, and putting an end to the gearing at this moment. This arrangement necessitates, therefore, that for the zero reading there should already be an active force—that is, a certain torsion of the spring, R; the counterweight, P, must exercise an excess of pressure upon the fixed end of the lever, F, as we have mentioned.

The following is the manner in which we have constructed this gearing of periodic but variable duration, all the parts of which are represented in Fig. 3. A ratchet wheel of large diameter, r, is mounted with weak friction obtained by the pressure of bent washers at the extremity of the axle A; it draws round the first wheel of the totaliser, T, by means of a stud, t, which pushes a slide belonging to this first wheel.

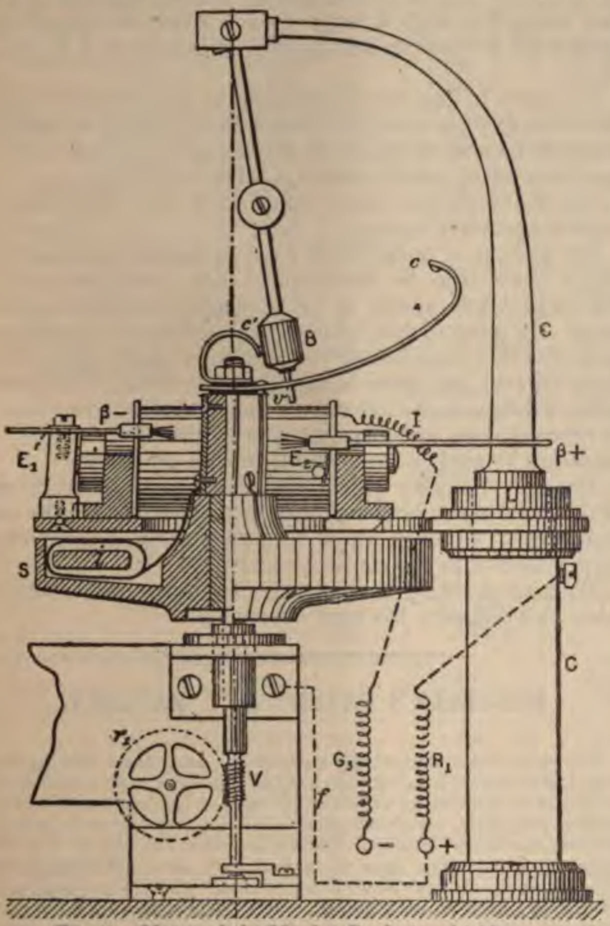


Fig. 2.—Motor of the Meylan-Rechniewski Meter.

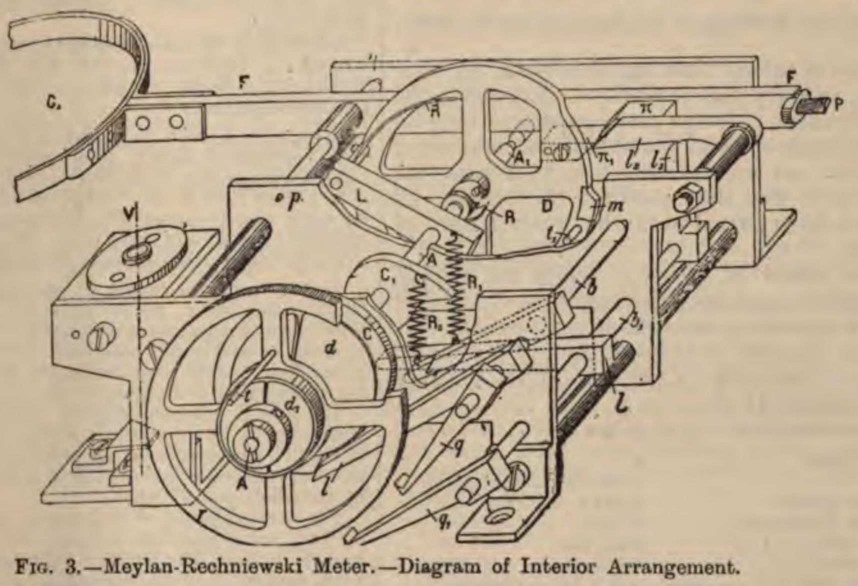


Fig. 3.—Meylan-Rechniewski Meter.—Diagram of Interior Arrangement.

This ratchet wheel, r, is furnished with two detents, $q\ q_1$, the first of which is always engaged before the commencement of the reading, and is liberated at the moment when this begins; while the other, q_1, which is normally disengaged, becomes so the moment the reading finishes.

For this purpose the first detent, q_1, which is fastened to and works with the axle b_1 and the lever l, is governed by the cam c, whose shape and the wedging effect upon A are such that the detent is put out of action at the precise instant that the reading commences, while it is brought again into play at the end of the turn by the action of the spring R_2.

On the other hand, the detent q is fastened to and works with the axle b and the lever l_3, which is maintained in place against the action of the spring R by a notch on the lever l_2. When the reading is finished the piece π_1 of the spring cam escapes from the piece π of the beam. At this moment, and under the action of a preliminary torsion, and of the torsion corresponding to the extent of the reading, the disc, D, which is cut away on a portion of its circumference, becomes raised by m of the lever l_2; the lever l_3 escapes, and the detent q immediately comes into play under the action of the spring R_1.

At the end of the turn a second cam, c_1, also fastened upon the axle A, by pressing on the lever l_1 fixed on b_1 pulls back the ratchet wheel q_1 and the lever l_3 into their place while stretching afresh the spring R_1.

This last operation naturally does not take place until after the first detent, q, has been re-engaged by the cam c, so that the ratchet wheel is not free until the moment of the following reading.

The regulation of the instrument is brought about very simply by assuring the simultaneous freeing of the detent q and the re-engagement of the detent q_1, when the electrodynamic pressure is nil; this regulation is brought about by the position on the shaft of the cam c and the adjustment of the weight, P.

Connections.—As we have said, the motor is wound in series, and forms part of the fine-wire circuit of the wattmeter and a rheostat. The connections of the shunt circuit are therefore those of Fig. 2, of which X would represent a rheostat and R_1 the coil of the wattmeter.

Each meter carries four terminals; the two first to the left, which are insulated, correspond to the positive main, and the positive wire to the lamps; they are connected by the thick wire of the galvanometer. The two others, which together form one connection, serve to fasten the negative main and the negative lamp wire. The shunt circuit is connected on one side to one of the positive terminals, and on the other to one of the negative terminals.

Calibration.—The calibration of our instruments is made in such a manner that the first dial of the totaliser indicates a multiple or a decimal part of the electric unit of work, the hecto-watt-hour (100 watt-hours).

Thus, for meters of lower capacity (100-110 volts 12 amperes), one division of the first dial corresponds to a deca-watt-hour (10 watt-hours). This calibration is made, for a type once settled upon, by altering in the desired direction the total resistance of the shunt circuit, which is about 2,000 ohms, the speed of all our motors being regulated previously so that the rotation of the main axle is made once in three minutes.

Series of Types.—The capacity of a motor is determined by two conditions, of which one depends upon the measuring apparatus, and the other on the extent of the measurements to be taken—that is, on the number of lamps to register—if it is desired that the meter must register from a single lamp upwards.

In fact, if an instrument has a sensibility such that it can mark with the approximation desired from unity up to *n* times this value, it will be sufficient to proportion the galvanometer in such a way as to make the minimum electro-dynamic pull correspond to the energy consumed by each lamp to obtain a meter for *n* lamps.

It will be sufficient to modify the winding of the galvanometer to obtain the types for the smaller capacities. But it will be necessary, in order to satisfy a practical condition, that all the galvanometers used do not themselves consume more than a very small amount of energy.

It seems at first view that we should fix upon a certain limit of loss of voltage—0·2 volt, for example—and to give to the instrument a resistance inversely proportional to the maximum current. Nevertheless, as the electro-dynamic pull is proportional to the volume of copper and to the loss of energy, and as this increases as the current increases in constant loss of voltage, this loss of voltage can be diminished as the size of instrument increases, while still obtaining more powerful pulls, a condition necessary to obtain great sensibility.

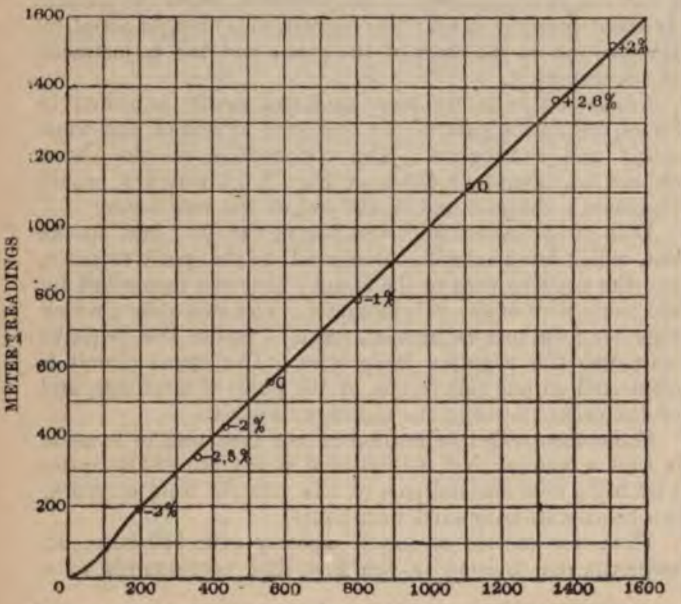


FIG. 4.—Watts Curve of Readings of Meylan-Rechniewski Meter.

The relative loss of energy thus decreases with the size. On the one hand, in every discontinuous reading meter, the sensibility or the range is always much greater as the size of the registering apparatus and the pull of the measuring apparatus is larger; we are led, therefore, to increase the size of the instrument with the capacity of the meters.

These principles have guided us in the establishment of our series of types.

Thus our first model of meter, of which the ratchet wheel has 300 teeth, measures from unity to 70 or 80; furnished with a galvanometer, whose resistance is 0·01 ohm, it forms our type of 12 amperes, and is capable of measuring from one lamp of 8 c.p. (30 watts) up to 40 lamps of 8 c.p., or 20 lamps of 16 c.p.

The principal constants of this type are :

Periodicity of readings......................	3′
Constant	1 division = 10 watt-hours
Resistance of shunt circuit	2,350 ω
Resistance between terminals............	0·01 ω
Maximum loss of volts	0·12 volt
Loss empty (100 volts)	4·5 watts
Maximum loss (100 volts 12 amperes)	4·5 + 1·5 = 6 watts
Maximum electro-dynamic couple	60 gramme-centimetres

It is easy to alter this type so as to measure up to 25 amperes by modifying the galvanometer, so that the maximum ampere-turns remain constant with the same weight of copper.

Our second type is capable of registering from one lamp up to 80 lamps of 8 c.p., or 40 lamps of 16 c.p.

For higher capacities it is necessary to increase the size of certain parts.

Fig. 4 represents the results given by a meter of type 2, the ordinates corresponding to the readings obtained on the meter, and the abscissæ represent the actual energy.

From an examination of this curve it is seen that with a meter constructed to register the consumption of 40 lamps of 16 c.p., it is possible to register the consumption of the first lamp, but with a large error. After five lamps are lighted the indications are correct within about 2 or 3 per cent.

The error in the total consumption will therefore be of this order (2·3 per cent.), on the condition that on an average a certain number of lamps are turned on at any one time, a condition which nearly always obtains in practice.

The readings have been taken from the meter during periods of several hours.

Our system of meter lends itself to various combinations which allow it to be transformed into a volt-hour meter, and its principle allows it to be applied to alternate currents. In point of fact, although the presence of the motor gives rise to a considerable retardation of phase (lag) of the shunt current, compared to the principal current, the electric balance does not give less exact results, while the frequency of reversal does not change; it will, therefore, simply be necessary to modify the rheostat in each given case.

The only difficulty which is presented is that by reason of this lag a much higher potential is required to make our motors act, although they do not sensibly absorb more energy than with the continuous current.

We shall probably have occasion to return to this subject when this difficulty has been overcome.

HELLESEN'S PATENT DRY BATTERY.

The want of an efficient dry battery has long been felt in both telegraphic and telephonic services, and perhaps even more for use in houses in connection with electric bells. After numerous unsatisfactory proposals, which failed to fulfil the requirements, greater success has been obtained during the last few years, and dry batteries which give general satisfaction are now coming into extensive use. It is evident that in cases where the liquids are subject to rapid evaporation, or where it is desirable to employ elements which, after their installation, require no further attention, and also in cases where portability is a condition to be fulfilled, dry elements will undoubtedly find their special field.

On the suggestion of Prof. Lommel, of the physical laboratory of the University of Munich, a series of experiments were conducted in November, 1889, by Mr. Heinrich Krehbiel, Dr. Narr, and Dr. Donle, in order to obtain an exhaustive comparison of the electrical qualities of six of the principal dry elements in existence—viz., those of Hellesen, Bender, Thor, Gassner, Jenisch, and Wolfschmidt.

A full report of these interesting experiments was published on August 1, 1890, in No. 31, Vol. II., of the *Elektrotechnische Zeitschrift*, of Berlin, containing a detailed account of the following investigations :

1. Change of the E.M.F. of the element on open circuit.
2. Variation of E.M.F. with temperature.
3. Determination of internal resistance.
4. Fall of E.M.F. on a closed circuit, and subsequent recovery on open circuit under the following conditions: (*a*) With an external resistance of three ohms, furnishing a strong current. (*b*) With an external resistance of 50 ohms, furnishing a weak current.

As the complete report of the Munich University is a very lengthy document, we only extract from it the principal data referring to that element which proved the most satisfactory—viz., Hellesen's—and quote only such results with regard to the other elements as enable their respective efficiencies to be directly compared with that of Hellesen's cell.

The E.M.F. was measured by an Edelmann's cylinder quadrant electrometer, by comparison with a Latimer Clark standard cell of 1·407 V (the coefficient for reducing the E.M.F. to the standard temperature being taken as 0·08 per degree centigrade, as given by Helmholtz and Kittler).

The measurement of resistances was effected by Kohlrausch's method, using alternate currents with the telephone introduced into the bridge. The Hellesen cells had the following dimensions : 8 cm. square by 16 cm. high (3¼in. square by 6½in. high).

The mean original E.M.F. in volts at 15deg. C., taken immediately after the receipt of the cells, was 1·415 V.

The E.M.F. of each cell was tested periodically during 2½ months, and remained, with slight variations, practically constant, no current, however, being taken from the cells during the time.

The E.M.F. was at 0deg. = 1·405 V, at 15deg. = 1·404 V, and at 30deg. = 1·404 V. Showing that the E.M.F. was practically unaffected by change of temperature.

The mean original internal resistance, taken immediately after the receipt of the cells, was 0·067 ohm; this resistance being lower than that of any of the other cells submitted for testing.

After these tests, one element of each kind was continuously closed for 36 hours through an external resistance of three ohms and

TABLE A.

	Time of closing and opening.	Hellesen.		Bender.		Thor.		Gassner.		Jenisch.		Wolfschmidt.	
		V.	%	V.	%	V.	%	V.	%	V.	%	V.	%
Closed.	0 hour	1·379	100	1·371	100	1·360	100	1·373	100	1·286	100	1·000	100
	1 ,,	1·347	97·7	1·327	96·8	1·295	95·2	1·266	92·2	0·859	66·8	0·542	54·2
	4 hours	1·306	—	1·298	—	1·256	—	1·208	—	0·725	—	0·413	—
	24 ,,	1·260	—	1·240	—	1·173	—	1·115	—	0·594	—	0·307	—
	48 ,,	1·241	—	1·219	—	1·112	—	1·004	—	0·521	—	0·290	—
	72 ,,	1·224	—	1·204	—	1·067	—	0·887	—	0·474	—	0·287	—
	96 ,,	1·207	87·5	1·192	86·9	1·033	75·6	0·842	61·3	0·436	33·9	0·286	28·6
Opened.	5 minutes	1·209	—	1·199	—	1·038	—	0·851	—	0·485	—	0·339	—
	60 ,,	1·214	—	1·222	—	1·071	—	0·864	—	0·564	—	0·366	—
	24 hours	1·297	94·1	1·280	93·4	1·169	86·0	1·071	78·0	0·950	73·9	0·412	41·2

TABLE B.

Closing period.	Hellesen.		Bender.		Thor.		Gassner.		Jenisch.		Wolfschmidt.	
	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%
1st	0·0279	100	0·0284	100	0·0280	100	0·0285	100	0·0197	100	0·0260	100
9th	0·0274	98·1	0·0276	97·0	0·0267	95 2	0·0276	96·9	0·0189	96·0	0·0243	93·4
17th	0·0271	96·9	0·0272	95·6	0·0264	94.2	0·0268	94·3	0·0186	94·2	0·0147	56·6
25th	0·0270	96·7	0·0267	93·9	0·0260	92·7	0·0257	90·0	0·0182	92·2	0·0109	42·1

TABLE C.

Closing period.	Hellesen.		Bender.		Thor.		Gassner.		Jenisch.		Wolfschmidt.	
	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%	Ampere-hours.	%
1st	0·2120	100	0·1959	100	0·1959	100	0·1943	100	0·0861	100	0·0948	100
9th	0·2051	95·0	0·1801	91·9	0·1656	84·5	0·1585	81·6	0·0823	95·6	0·0612	64·6
17th	0·1872	88·5	0·1761	89·9	0·1495	76·3	0·1308	67·3	0·0797	92·6	0·0401	42·3
25th	0·1779	83·9	0·1619	82·6	0·1206	61·6	0·1138	58·6	0·0762	88·5	0·0316	33·3

periodically tested; the result obtained with Hellesen's cell being the following:

At the beginning	0·066 ohm.
After ½ hour	0·071 ,,
,, 1 ,,	0·074 ,,
,, 4 hours	0·087 ,,
,, 8 ,,	0·096 ,,
,, 12 ,,	0·105 ,,
,, 36 ,,	0·172 ,,

The experiments proved that all the elements increased somewhat in resistance, when short-circuited in this way for a long time.

The next and most important trials refer to the recuperative power possessed by these cells. For that purpose they were closed for 60 minutes through an external resistance of 50 ohms, after which time the circuit was opened and the amount of recovery observed at intervals. This closing and opening of the circuit was repeated 25 times, the circuit of each element being closed for 60 minutes at a time, and the elements then left on open circuit for 24 hours, thus imitating in some degree the demands required in actual work.

The following table shows the decrease of the E.M.F. during the 60 minutes of closed circuit, and the recovery durirg the 24 hours of open circuit, given by the first of these 25 tests.

HELLESEN'S ELEMENT.

Closed.			Opened.		
Time of closing.	V.	Per cent.	Time of opening.	V.	Per cent.
0 minute.	1·420	100	2 minutes.	1·394	98·2
2 minutes.	1·405	98·9	5 ,,	1·397	—
5 ,,	1·402	—	10 ,,	1·397	—
10 ,,	1·399	—	20 ,,	1·398	—
20 ,,	1·398	—	30 ,,	1·399	—
30 ,,	1·397	—	60 ,,	1·402	—
60 ,,	1·391	98·8	24 hours.	1·411	99·4

All the elements, after 24 hours of open circuit, regained very nearly their original E.M.F.

The E.M.F. before the twenty-fifth test and its value as compared with the first test, was as follows:

Volts 1·369=96·4 per cent.

A far more crucial test was then made by closing each element continuously for 96 hours through an external resistance of 50 ohms, after which time the circuit was opened for 24 hours, and the amount of recovery observed. The results are contained in Table A.

According to this table the Hellesen element suffered the least loss in E.M.F. after 96 hours' work on closed circuit, retaining 1·207 V, or 87·5 per cent. of its original value; but the table also shows that the Hellesen element possessed the greatest recuperative power, attaining after 24 hours' rest 1·297 V, or 94·1 per cent. of the original value before the 96 hours of closed circuit.

After these experiments were brought to a close, a final test was taken by closing the cells for 60 minutes through an external resistance of 50 ohms, and then leaving them open for 24 hours. The following table gives the E.M.F. in volts during this test:

	Time.	Hellesen	Bender.	Thor.	Gassner.	Jenisch.	Wolfschmidt.
Closed.	0 min.	1·361	1·359	1·312	1·284	1·243	0·476
	5 mins	1 343	1·332	1·265	1·205	1·017	0·343
	30 ,,	1·338	1·318	1·217	1·184	0·906	0·277
	60 ,,	1·321	1·309	1·189	1·170	0·865	0·267
Open.	24 hr's.	1·349	1·352	1·304	1·285	1·225	0·475

The Munich investigation contains also the calculation of the ampere-hours from the values of current observed, and thus of the amount of work done by each element.

Table B gives the ampere-hours of the first, ninth, seventeenth, and twenty-fifth period of 60 minutes, when the circuit was closed through an external resistance of 50 ohms.

Table B demonstrates the superiority of the Hellesen element, the value of the ampere-hours during the twenty-fifth period being actually 96·7 per cent. of that furnished during the first period of closed circuit. This superiority is still more clearly shown by the ampere-hours which were furnished by the crucial test of the 96 hours on closed circuit, and which are as follows:

Hellesen	2·3915	ampere-hours
Bender	2·3400	,,
Thor	2 1435	,,
Gassner	1·9374	,,
Jenisch	1·0347	,,
Wolfschmidt	0·5967	,,

The ampere-hours resulting from the final test, and the percentage in value compared with that of the very first period of closed circuit, are given below, and here also the superiority of the Hellesen element is maintained; the elements having been on closed circuit for more than five days, four days being continuous.

Hellesen	0·0267	ampere-hours	95·6	per cent.
Bender	0·0262	,,	92·1	,,
Thor	0·0242	,,	86·4	,,
Gassner	0·0237	,,	83·2	,,
Jenisch	0·0183	,,	99·8	,,
Wolfschmidt	0·0058	,,	22·4	,,

In the foregoing experiments the circuit was closed through an external resistance of 50 ohms, but similar experiments were at the same time carried out through an external resistance of only three ohms. In these latter experiments the time of closed circuit was, however, only 30 minutes instead of 60 minutes; the number of periods being as before, 25 respectively, at intervals of 24 hours each.

The results obtained with Hellesen's cells after the first period of 30 minutes' work and 24 hours' rest are given in the following table, and it appears that the Hellesen element suffers the least polarisation.

Time of closing.	Hellesen.		Time of opening.	Hellesen.	
	V.	Per cent.		V.	Per cent.
0 minute	1·410	100	2 minutes	1·288	91·3
2 minutes	1·343	95·2	5 ,,	1·295	—
5 ,,	1·325	—	10 ,,	1·303	—
10 ,,	1·305	—	15 ,,	1·314	—
15 ,,	1·299	—	20 ,,	1·317	—
20 ,,	1·274	—	30 ,,	1·323	—
30 ,,	1·261	89·2	60 ,,	1·332	—
			24 hours	1·385	98·2

The following table shows a similar but more severe test than that of the preceding table, the elements having been close-circuited during 24 hours through an external resistance of three ohms and then given 24 hours' rest.

Time of closing.	Hellesen.		Time of opening.	Hellesen.	
	V.	Percent.		V.	Per cent.
0 hours	1·298	100	5 minutes	0·605	—
1 hour	1·007	77·6	60 minutes	0·776	—
4 hours	0·853	—	24 hours	1·084	835
24 hours	0·344	26·0	—	—	—

Table C gives the values of ampere-hours at the first, ninth, seventeenth, and twenty-fifth period when closed through an external resistance of three ohms. The duration of each period being 30 minutes.

The elements, when closed during 24 hours through an external resistance of three ohms, gave the following aggregate ampere-hours:

Hellesen	5·0792	ampere-hours.
Bender	4·9898	,,
Thor	3·4552	,,
Gassner	2·6670	,,
Jenisch	1·2236	,,
Wolfschmidt	1·6168	,,

This investigation of the comparative efficiency of the above elements was concluded by the experiment of regenerating the partially exhausted cells by a treatment similar to that of a secondary battery—*i.e.*, by sending a current from two Bunsen elements during two hours through the cells. The elements thus regenerated were again worked for five periods of closed circuit (each period of 30 minutes' duration) through an external resistance of three ohms.

The following table shows the E.M.F. of the partially exhausted Hellesen's cell before and after its regeneration by the two Bunsen elements, and also the E.M.F. of the last period of closed circuit, with the recovery after being on open circuit for 24 hours.

E.M.F. IN VOLTS.

		Hellesen.
Before	Regeneration.	1·225
Immediately after		1·994
24 hours after		1·580
Closed through three ohms.		
0 minutes		1·352
5 ,,		1·096
20 ,,		1·008
30 ,,		0·979
Opened.		
24 hours		1·309

The ampere-hours calculated from the results of this last test after the regeneration, and the percentage of the value of the last period before regeneration, were found to be as follows:

Hellesen	0·1656 ampere-hours	= 172·9 per cent.
Bender	0·1384 ,, ,,	= 114·3 ,,
Thor	0·1005 ,, ,,	= 148·9 ,,
Gassner	0·1590 ,, ,,	= 151·0 ,,
Wolfschmidt	0·0556 ,, ,,	= 134·9 ,,

The Munich report contains the following conclusion as the results of this exhaustive and carefully conducted series of experiments:

"The most efficient elements, even for circuits of a small external resistance, are Hellesen's and Bender's elements. Hellesen's element excels Bender's by having somewhat less polarisation and much smaller internal resistance; it has, however, when exhausted by long working, not quite so much recuperative power as Bender's.

"A similar relationship exists between Thor's and Gassner's element. In a circuit with a small external resistance, Gassner's is less constant than Thor's, but the former has the advantage of more recuperative power, even after the E.M.F. has been reduced to a very small value.

"Jenisch's and Wolfschmidt's elements are, in consequence of their very rapid polarisation, unsuitable for giving even approximately constant currents; hence they are only applicable when duration of closed circuit is very short.

The above experiments prove that dry elements are well adapted for many practical purposes, especially for telegraphic, telephonic, and similar services, and the considerable power of recovery possessed by such elements gives them a long duration of life.

Hellesen's elements being able to produce strong currents during a long period are well adapted to supersede the cells of Leclanché, Meidinger, and similar types, and in many cases even those of the Daniell types.

Besides the electrical advantages shown in the tables accompanying the Munich report, there are various other advantages of a purely practical character possessed by such cells when compared with wet elements. The former are transported with far more facility, being always, and without any previous preparation, ready for use, and require no inspection or attention until they are completely exhausted.

Messrs. Siemens Bros. and Co., 12, Queen Anne's-gate, Westminster, London, are the sole manufacturers in England of Hellesen's patent elements.

LEGAL INTELLIGENCE.

COOPER v. GREAT WESTERN RAILWAY.

Electric Lamps Damaged in Transit.

In the Westminster County Court on the 29th ult., the case of Cooper *v.* the Great Western Railway was before his Honour Judge Bayley, and was an action by the plaintiff to recover the value of two electric lamps which he alleged had been smashed while in the care of the defendant company for the purpose of transit from London to Swansea.

The **Plaintiff** (Mr. Cooper) was called, and said that in July last year he forwarded the lamps in question to a customer at Swansea. The box containing them was entrusted to the defendants to forward on to Swansea. Shortly afterwards he received a letter from his customer stating that the lamps were smashed and useless, and had been returned. A few days afterwards the box was returned per Midland Railway, and the contents were found to be broken up. The defendant company were then communicated with as to compensation for the damage, but as they refused to recognise his claim the damaged articles were returned to them, and the present action was brought to recover some recompense for the damage done.

John Frost, a servant in the plaintiff's employ, said he personally superintended the packing of the lamps. He made a box purposely for them in order that they should travel safely. He also lined the box with any quantity of paper, and it was impossible for the lamps to have been broken unless they had been very badly used.

The **Solicitor** for the defendant company submitted that he was entitled to judgment, as the plaintiff had totally failed to prove negligence on the part of the defendants. The plaintiff's own customer had written saying that the goods were improperly packed, and in the face of that letter he submitted that no liability could attach to the company. He (defendants' solicitor) thought the best thing the plaintiff could do would be to take back his lamps and say no more about the matter.

Without hearing any evidence for the defence, his **Honour** said the plaintiff had failed to make out his case, and therefore judgment would be for the defendants with costs.

SOMERTON v. LONDON ELECTRIC SUPPLY CORPORATION.

Claim for Damages.

In the Westminster County Court on the 28th ult., the case of Somerton v. The London Electric Supply Corporation was before his Honour Judge Bayley, and was an action by the plaintiff to recover damages against the defendant company for alleged wrongful dismissal from their service.

The **Plaintiff** (Mr. Edward Somerton) was called, and said he entered the service of the defendant company about May 22nd last year, as a shorthand writer at a salary of £90 per annum. The terms of the engagement were that a month's notice was to be given on either side. He had not been long in the employ of the defendants before he was discharged without any notice. He now claimed a month's wages in lieu of notice, and a further month for wrongful dismissal.

For the defence it was submitted that there was in existence a written agreement, and the plaintiff's case could not be sustained without it.

The **Solicitor** for the plaintiff said it was true there was a written agreement, but, unfortunately, it was not stamped, and therefore could not be put in as evidence.

His **Honour** said the agreement could not be put in as evidence unless stamped, and the plaintiff's case could not go on without it.

The defendant's **Solicitor** asked for judgment.

The learned **Judge** entered a non-suit, but refused to allow any costs.

COMPANIES' MEETINGS.

ELMORE'S FOREIGN AND COLONIAL COPPER COMPANY.

The second annual general meeting of this Company was held on Thursday week, Sir J. H. Morris, chairman, presiding.

Having explained why the Board agreed to take £50,000 of the French Elmore's Company's debentures, the **Chairman** referred to the profit and loss account. The amount received from the sale of the French and Hungarian patents was £257,750, from which £30,000 had been deducted to represent the original capital value of the patents sold, leaving a net amount, after adding items for interest and transfer fees, of £228,341. 19s. After allowing for sundry working expenses there was a balance carried down of £222,772. Out of this they had paid an interim dividend £4 per priority share, which absorbed £60,000. Under the articles the Directors were entitled to 5 per cent. of the net profits of the Company after paying 10 per cent. per annum upon the priority share capital—this amounted to £10,605. It was a large amount, but was fixed by the articles, and was for work done. They would take it in any way the shareholders might determine. The balance carried forward was £152,167. The total on the credit side of the balance-sheet was £319,192, which was balanced by share capital £120,000, and the sum due to sundry creditors £47,025. In a circular issued on November 13 last it was proposed to form a trust company to take up the securities held by the Company. There were three courses open to them: (1) to form an Elmore Trust Company; (2) to hold the shares themselves, realise the profits, and distribute them to the shareholders; (3) to alter the articles, and thus become empowered to distribute the shares and debentures to the shareholders as if they were cash. The Chairman then moved the adoption of the report and accounts, which was seconded by **Mr. John Macfarlan**, and carried.

The **Chairman** next moved: "That a dividend of 20 per cent., or £1 per share, less income tax, be paid on Feb. 4 upon the priority share capital, making, with the interim dividend of £4 per share paid on December 8 last, a total dividend of 100 per cent. for the nine months ending December 31 last."

Mr. Edward J. Carson seconded the resolution, which was agreed to.

The **Chairman** said it was the wish of the Directors to consult the interests of the shareholders in regard to the realisation of the Company's securities; therefore, he was quite ready either to call a special meeting to consider the question or to confer with a committee of shareholders.

After some discussion it was decided to leave the matter in the hands of the Board, with the view of calling a special meeting at a subsequent date.

The retiring Directors were re-elected, as were also the Auditors.

The following resolution, which was passed by a general meeting on December 29, was confirmed: "That once at least in every year the Board of Directors shall lay before the Company in general meeting a statement of the income and expenditure for the past year, made up to December 31 then last past, instead of to March 31, as provided in Clause 113 of the Company's articles of association."

A vote of thanks to the Chairman and Directors terminated the proceedings.

CITY AND SOUTH LONDON RAILWAY.

A special general meeting of the shareholders of this Company was held at the offices, King William-street, E.C., on Tuesday, to consider a Bill which has been deposited in Parliament, by which powers are sought to construct an extension of their line from the City to the Angel at Islington. The chairman, Mr. C. G. Mott, presided.

The **Secretary** having read the notice convening the meeting, and the **Solicitor** having given the gist of the chief clauses in the Bill, from which it appeared that the construction of the railway will be identical with that of the City-Stockwell line, and that the capital to be obtained is £660,000 in £10 shares, with borrowing powers up to £220,000,

The **Chairman** said that the meeting was called simply to consider whether they would proceed with the Bill which had been provisionally introduced into Parliament for the construction of an extension of this (the City and South London) line from King William-street to the Angel at Islington. It had never been the desire of the Directors of that Company to proceed with anything in connection with that line at all hastily. They had from time to time, as the shareholders knew, been asked to go for various extensions; but except the small one at the Clapham end, which they had obtained powers for last year, they had declined all such proposals up to the present. Their desire was rather to consolidate and work their railway satisfactorily before they proposed to extend it, and that had been the view the Directors had taken all along. Last year they declined this very line (the Islington) when proposed to them. The result was that they were threatened with another Bill—viz., the Central London—in which the promoters proposed to take and occupy the ground, which would have prevented the City and South London Railway from ever being extended into the City of London. Some of the best traffic for a railway of this kind was to be had ultimately from the busy portions of the City, and it did not appear desirable that their road should be permanently blocked so that they could never go for that traffic. On that account they thought it wise that notice should be given this session for a Bill such as that (which had been read) was to obtain for them the road into the City at any time they desired to go there. He thought this line could be carried out at a comparatively small expense per mile, and would go through one of the very busiest traffics they could well have in the City. It would go by the Bank, Moorgate-street, and the City-road, and so far as the Directors could judge it would pay quite as well as, perhaps better than, their existing line. He would rather that the matter had been postponed, but it did not appear to the Directors safe to do so at the present moment, and they thought they had better obtain the Act. As to the exact time of carrying it out, and the mode, whether as part of the capital of the existing line, or as a separate concern, these were matters which, if the Bill was obtained, the shareholders would have to decide for themselves at a later date. That was their position now. The Directers would have postponed any further action if they could have done so safely, but they thought that it was desirable in the shareholders' interests that the Bill should be obtained if possible, and that the line would be a good one. The great object of a line of that kind was this. Morning and evening there was a very large rush of traffic into and from the City, as much as their line could take, but during the middle of the day the trains were not full. This was the experience of all Metropolitan railways, more or less, and their great object in order to make a good dividend was, as far as possible, to fill up these midday trains. Now the effect of another line, such as the Islington extension, would be that they would largely improve the midday traffic on their existing line, and the latter would improve the midday traffic upon the former. Therefore, they would have a better chance of a dividend on their existing line, if a line such as the proposed one were working. It was on account of these facts that the Board were disposed to recommend that the Company should go on with this Bill. The immediate effect of their proceeding had been that they had prevented the Central London Company from occupying the ground. They had altered their Bill, but if they (the City and South London) withdrew theirs, they would leave the ground again unoccupied. As regarded the City-Stockwell railway, they had as yet only been working for six weeks. On a new line like that they had had a great many difficulties to contend with in the working of an undertaking which, as the shareholders knew, was practically unexampled in the history of railways in this country. A service such as they had started, and hoped to still further develop, had never been attempted on any railway. With the exception of small portions of the District Railway service, no complete railway had run trains at the same rate or number as this line was running, and he thought they had reason to be extremely satisfied on the whole with the working of their electrical line. They had seen many paragraphs in the papers complaining of breakdowns. They were, unfortunately, very strongly before the public at the moment, and notice was taken of everything on that line in a way which was not the case with other railways. They had run up to the present time about 11,000 trains. During that period they had had with their engines, which had been the chief causes of delay, 18 failures in running. He did not think they would say that was a large number out of 11,000 trains run. The number of trains working on their line was very large, and it was quite impossible that such a large number should be run without some accidents occasionally. That there should have been only 18 failures of engines out of 11,000 runs was altogether creditable to the electrical system. They were doing their best to reduce that number, and get rid of failures, if possible, altogether; that they should be able to do so did not seem very likely, looking at the history of human inventions. But they would so minimise the delays when they occurred that the public would feel no inconvenience. The result of the above-mentioned paragraphs had been that many people who would have travelled with them had supposed that the line was stopped and did not go, and the traffic had been damaged. He was satisfied from what he saw now, however, that they had a steadily-improving traffic and a satisfactory result from it. The expenses of working so far as electricity was concerned had turned out satisfactorily, and were quite equal to what they expected so far as economy went. On the whole the prospects of the line were by no means bad. As regarded the new Bill, the Directors were quite in the shareholders' hands in the matter, but he thought they would be wise to let the Bill go on, obtain the powers, and deal with the question of using them as they might think fit later on. He moved that the Bill, which had been read to the meeting, be approved.

This was seconded by **Mr. Hubbard.**

In answer to a shareholder, the **Chairman** said that five years was the usual period given in a Bill for constructing the works, and if they did not want to do them in that time, the plan was to go to Parliament for an extension.

Mr. Broad objected to the expense being incurred in getting this Bill.

The **Chairman** said they did not want to proceed with the Bill if the shareholders did not like it. They had gone in for it themselves rather reluctantly, as a protection to the shareholders. If they thought it better to run the risk of withdrawing the Bill, because it was a very considerable risk, it was for them to say so. The Directors had given them an opportunity of discussing the question, and it was for them to decide.

Mr. Broad moved that the Bill be withdrawn.

In answer to a question as to who would have to pay the expense of getting the Bill, the **Chairman** said the shareholders of the existing line; that it was not an expensive Bill to get through, and might cost £1,500.

A **Shareholder** thought that the present line should be completed and proved and tested in every possible way, and when they had made it pay, extend if they liked; or if other people were going in they could take shares in their Company. He thought the Bill should be withdrawn.

Another **Shareholder**, who represented £75,000 of stock in the Company, said that he had not heard yet, but thought from the deposited plans that he saw that the proposed junction between the new line and the existing line was not, in fact, a junction at all. The proposed method was to have a foot subway between the two, and it was not, therefore, a physical junction between the two railways. If that was so, what the Chairman had said about occupying the ground would hardly be the case, because unless they had a physical junction it would still be open to any other Company to ask for a physical junction with the rails of that line and power to enter into its terminus. He had not seen these plans until then, and would like to have an opportunity of considering the matter. The shareholders knew little or nothing about the proposal, and had no opportunity of considering it, and although the notice given to the shareholders was in accordance with the Act of Parliament, it contained no information, and, under the circumstances, he thought it would be well to adjourn that meeting for a week to give them an opportunity of looking into the matter.

The **Solicitor** having explained that the meeting could be adjourned if they liked,

The **Chairman** said they could adjourn to the general meeting on the 24th inst.

The **Shareholder** who had last spoken then moved the adjournment of the meeting to the ordinary general meeting on the 24th inst. His own opinion was that if the objections could be got rid of, the scheme would be an addition to the Company. Besides, by the date above mentioned, they would know more about the working of their own line.

Mr. Broad saw little use in adjourning.

Mr. W. A. Smith seconded the adjournment.

A question having been asked as to the capital of the new line, the **Chairman** explained that it was larger than for the existing, £660,000 as against £600,000, because in going through the City it might be necessary to pay a large sum for station sites, and they were obliged to have sufficient capital in the Bill to cover this cost.

A **Shareholder** asked whether a physical junction between the existing and proposed lines was possible, and

Mr. Greathead, engineer to the line, said it was.

The adjournment of the meeting was then put from the chair, and carried.

A desultory conversation then ensued, during which the **Chairman** said, with reference to a question as to why the City and South London line was not worked on Sundays, that they must have patience. The staff were employed night and day, Sunday and every day. They had to feel their way, and the delays and difficulties were all capable of remedy and being remedied; but they could not do everything in six weeks. He thought they would be perfectly satisfied by-and-by, as no stone was being left unturned to make the line a success. There were no trains running on Sunday, but the time was not far distant when they would be.

A hearty vote ot thanks was accorded to the Chairman, on the motion of **Mr. W. A. Smith.**

PROVISIONAL PATENTS, 1891.

JANUARY 26.

1390. **An improved incandescent electric lamp.** Ernest Boehm, 42, Little Britain, London.

1396. **Improvements in arc lamps.** Francis Murray Newton, 46, Lincoln's-inn-fields, London.

1425. **Improvements in storage batteries.** Alfred Julius Boult, 323, High Holborn, London. (William Roberts, Canada.) (Complete specification.)

JANUARY 27.

1432. **Improved manufacture of carbon filaments for incandescent electric lamps.** Carl Bollé, New Bridge-street, Manchester. (William M. B. Keen, United States.)

JANUARY 28.

1527. **Improvements in and connected with apparatus for receiving electrical signals.** Thomas Alexander Garrett, 128, Clerkenwell-road, London.

1528. **Improvements in the method of cooling magic lanterns, resistance and other optical or electrical apparatus liable to get overheated.** Charles Walter Cox, 6, Lord-street, Liverpool.

JANUARY 29.

1599. **Improvements in apparatus for stopping any waterwheel or other motor used in generating electricity.** William Scott Elliot, 154, St. Vincent-street, Glasgow.

1639. **Improvements in or connected with distribution of power by alternating currents with the aid of condensers, alternate-current motors, fuses, and electrostatic measuring instruments, and improvements in telephone systems.** James Swinburne, Broom Hall Works, Teddington.

1672. **Improvements in laying or running wires for electric lighting.** William Turner Lord, Stamford Brook Villa, Hammersmith, London.

1680. **A new or improved process for the manufacture of wire for transmitting electric currents.** Alphonse Edouard Tavernier, 4, South-street, Finsbury, London.

JANUARY 30.

1741. **Improvements in electric welding, and in apparatus therefor.** Henry Howard, 24, Southampton-buildings, London.

JANUARY 31.

1779. **Improvements in motors and dynamos for use in mines and other places.** Wilson Hartnell, Volt Works, Leeds.

1788. **Improvements in the construction of battery elements.** Mark Bailey, 21, Finsbury-pavement, London.

1804. **An improved arrangement of shunt for electric motors.** George Frederick Redfern, 4, South-street, Finsbury, London. (Wirth and Co., agents for W. Lahmeyer and Co., Germany.)

1818. **A new or improved preparation of soluble bichromates and sulphuric acid for use in charging voltaic batteries and for other purposes.** John Benz Winder, 7, Staple-inn, London.

SPECIFICATIONS PUBLISHED.

1890.

836. **Long telephonic circuits.** Gwosdeff and Bunge. 8d.

873. **Electric supply meters.** Perry. 8d.

1306. **Galvanic dry elements.** Smith (Hellesen). 6d.

2091. **Secondary batteries.** Thompson (The Gibson Electric Company). 8d.

2653. **Electric meters.** De Ferranti. 8d.

2759. **Lighting railway trains by electricity.** Timmis. 8d.

3841. **Electric conductors.** Siemens Bros. and Co. (Taylor). 6d.

3842. **Electric circuit breakers.** Siemens Bros. and Co. (Taylor). 6d.

13319. **Electric bells, etc.** Townley. 8d.

15547. **Electric current circuits.** Iliffe and Teaque. 8d.

16064. **Electrical batteries.** Pumpelly and Butterworth. 6d.

16653. **Measuring the strength of electric currents.** Currie. 6d.

17181. **Electric switches.** Allison (McGregor and others). 8d.

18412. **Electric batteries and lighters.** Robertson. 6d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended January 30 amounted to £6,215.

City and South London Railway.—The receipts of this Company for the week ended January 31 amounted to £704.

Direct Spanish Telegraph Company.—For the month of January the receipts show a decrease of £268 as compared with the corresponding period.

West India and Panama Telegraph Company.—The receipts for the half-month ended January 31 show an increase of £425 as compared with the corresponding period.

Venezuela Telephone Company.—The coupons on the debentures of this Company, now due, are payable on presentation at the Consolidated Bank, Limited, 52, Threadneedle-street, E.C.

Woodhouse and Rawson United.—The Directors have declared an interim dividend at the rate of 15 per cent. on the ordinary shares, and 8 per cent. on the preference shares, in respect of the profits to December 30 last.

Western and Brazilian Telegraph Company.—The receipts for the week ended January 30, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,996.

Cuba Submarine Telegraph Company.—The Directors, after providing for the dividend on the preference shares and placing £4,450 to the reserve fund, recommend a dividend on the ordinary shares at the rate of 8 per cent. per annum, tax free, carrying forward £715.

Smith's Patents, Limited.—Registered by Newman, Hays, and Co., 31, Abchurch-lane, E.C., with a capital of £5,000 in £1 shares. Object: to carry on the business of indiarubber manufacturers and merchants in Great Britain and elsewhere, in accordance with an agreement made January 22 between J. S. Smith of the one part and John Cunningham, on behalf of the Company, of the other part. Registered without articles of association.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Snpply	5	1½
Swan United	3½	5
St. James'	—	6
National Telephone	5	4½
Electric Constrnction	10	7¼

NOTES.

Berlin Tramways.—The Allgemeine Gesellschaft of Berlin is erecting an electric tramway about six miles long at Gera.

Cavendish Laboratory.—Mr. R. T. Glazebrook, of Trinity College, has been appointed assistant director of the Cavendish Laboratory.

Ship Lighting.—The "Ottawa," a new screw steamer built by Messrs. Stephen and Sons, Glasgow, is luxuriously fitted throughout with electric light.

Matlock Bath.—There is a proposal to light Matlock by means of power from the river, and the engineer of the Local Board will shortly submit a report.

New Peru and Chili Cable.—The "Silvertown" has been reported from Arica, all well. She completed the cables between Chorillos, Yquique, and Valparaiso on February 2.

Cambridge Appointments.—Mr. G. F. C. Searle, M.A., of Peterhouse, and Mr. S. Skinner, M.A., of Christ's College, have been appointed demonstrators of experimental physics.

Duke of Westminster and the Electric Railway. In the House of Commons a petition has been presented against the Central London Railway Bill by the Duke of Westminster.

British Association.—At a conference of foreign consuls in Cardiff this week it was agreed to take steps for inviting distinguished foreign scientists to the meeting of the British Association.

Training Cannons by Motors.—Electric motors are being applied in France, at the La Seyne works, to train heavy cannons for armour-plated vessels, the dynamo supplying current being placed below the bridge.

Leeds.—The Electric Light Committee of the Leeds County Council have again discussed the question of electric lighting at considerable length, and requested Mr. Hewson, the borough engineer, to obtain further information.

St. Martin's Free Library, opened yesterday by Mr. Gladstone, is lighted by electric light. The Metropolitan Supply have undertaken to supply current until the London Electric, in whose district it is, are in a position to do so.

Oxford.—Before the Oxford City Council, an application was made by the Electric Installation and Maintenance Company, Limited, for an extension of time under section 7 of the Oxford electric lighting order, and it was granted.

The St. James's Theatre, whither Mr. Geo. Alexander has betaken himself, *vice* the Avenue, was opened by its new manager last week. It has been magnificently upholstered by Messrs. Oetzmann, of Hampstead-road, and is lighted electrically.

Substitute for Guttapercha.—Senhor da Costa, a Portuguese scientist, is reported from Goa to have discovered an excellent substitute for guttapercha in the solidified sap of the nivol-cantem, which grows wild in hedges in the Cencan district.

Patent Office.—Mr. Goschen, in answer to a question with reference to the surplus of £93,534 at the Patent Office, stated that this surplus, or a large part, would be applied to providing additional accommodation and not to reducing fees to patentees.

Tamworth.—At the meeting of the Tamworth United District Water Works Committee, the tender of Mr. H. Hicklin was accepted for laying telephonic communication between the offices of the committee and the pumping station at Hopwas, the price being £43. 10s.

Charterhouse School, though removed to Godalming, must still be considered as part of London, and is intending to do as London is now doing, introduce the electric light. The head master, we learn, is making determined endeavours to have the new illuminant introduced at once.

Grimsby.—There is talk at Scunthorpe, New Grimsby, about the electric light. The Local Board approached Lord St. Oswald about leasing some land that the gas works stand on, and were advised by him to have the electric light. The proposition is by no means badly received.

Hastings.—At its annual meeting, the Hastings Electric Light Company declared a dividend at the rate of 5 per cent. for the last nine months. The company are negotiating for the electric lighting of St. Leonard's Pier. A report of the meeting is unavoidably held over.

Electric Welding.—Two Belgian civil engineers, M. Lagrange and M. Paul Hoho, have perfected a system of electric welding differing essentially, it is stated, from that of Elihu Thomson. The process will be exploited in Belgium by the Julien Electric Company, of Brussels.

Electricians' Exhibition.—A third annual exhibition of engineers, electricians, builders, and ironmongers will be held in the Royal Agricultural Hall from April 23 to May 2, under the management of Mr. H. Hetherington, 42, New Oxford-street. Applications for space can now be received.

Hull.—Messrs. Baily and Grundy, of Paddington, have just completed the lighting of Messrs. Pearson and Bailey's large seed-crushing mills. The installation comprises about 200 16-c.p. lamps. The work was carried out under the direction of Mr. J. E. Tongue, manager for Messrs. Baily and Grundy.

Newcastle Telegraphs.—For the working of the Newcastle telegraph wires 3,890 battery cells are used, and it will interest electricians to notice the rate at which the Fuller battery is displacing the Daniell. There are in use at the Newcastle Post Office 2,420 Fuller cells, 1,270 Daniells, and 200 Leclanchés.

Fire Alarms for Coventry.—The Fire Brigade Committee of the Coventry City Council have requested the city surveyor to ascertain the cost of laying and maintaining communication, by means of electric bells, between the police station and the residences of the members of the fire brigade, for summoning them in case of an alarm of fire.

Portsmouth.—At a meeting of the Electric Lighting Committee last Friday morning, it was decided to recommend the Town Council to take the management of the electric lighting works in the borough instead of leasing the powers granted the Corporation to a private company. The Council is asked to adopt the low-tension system, whereby the danger of overhead wires is avoided.

Liverpool. — The Liverpool Electric Light Company wish to obtain power to extend their supply over a much larger area in the city than their present powers enable them to do. On making their application to the Lighting Sub-Committee, after explanations and considerable discussion, it was decided to decline to accede to the extension on the terms submitted by the company.

Manchester.—On the presentation of the minutes of the Manchester Gas Committee for approval, Mr. J. Brooks said he thought it was desirable to inform the Council that the Electric Lighting Committee were actively engaged investigating the best mode of supplying that light to the public. A report would shortly be presented to the Council as to the manner in which it was best to be done.

German Exhibition.—The Gulcher (New) Electric Light Company, of Battersea, we hear, have obtained the whole of the electric lighting of the German Exhibition this year to be held at Earl's Court. This will make the third year that the same company has lighted up the same buildings and grounds, and if this year is as great a success as the past two years it does the company great credit.

A Runaway Engine.—An awkward accident occurred at Lynn, Mass., which ought to have been avoided by the use of a proper governor. An electric station caught fire and the wires carrying current were burnt. Relieved of the work, the 700-h.p. engine started off, became unmanageable, and the flywheel was broken and scattered in all directions by centrifugal force, with much damage to the building.

Commissioners of Sewers.—In view of the imminent lighting of the City by the Commissioners of Sewers, the chairmanship of that body for the current year has been an object of keen competition. The contest was this week fought by three gentlemen, under the presidency of the Lord Mayor himself. Eventually Mr. Deputy Sheppard Scott headed the poll, and was declared to be duly elected.

Telephone on Shipboard.—Most of the French navy have been fitted with special telephone sets by the Société Générale des Téléphones, the parts being constructed so as not to be damaged by damp, even if dipped in sea-water for several hours. The line has five wires with a distinct circuit for the bell. Experiments on board the "Devastation" show that speaking is distinct even when firing big guns.

Telephone at Newcastle.—The Post Office exchange at Newcastle now has about 600 subscribers, and in anticipation of a large increase when the existing patents run out in July, the department is introducing the latest and most costly form of multiple switchboard, whereby inter-communication will be greatly facilitated for 1,000 subscribers. The National Telephone Company have one for 5,000 connections.

South Kensington and Paddington Subway.—A specially convened meeting of the Paddington Vestry has, by two to one, decided not to oppose the scheme for the construction of an electric railway from South Kensington to Bishop's-road, Paddington, provided the promoters give an undertaking to insert in their Bill protective clauses as regards the sewers and other matters which are under the jurisdiction of the Vestry.

Ipswich Asylum.—Tenders are invited for providing and fixing the engine and all necessary plant and appliances for lighting the Borough Asylum by electricity. The premises are about two miles from Ipswich railway station, and can be viewed and further particulars obtained on application to the medical superintendent at the asylum. Tenders, endorsed "Tender for Electric Lighting," to be sent to the chairman of the committee, at the asylum, before March 4.

Eastbourne.—At the Eastbourne Town Council, a letter from the Board of Trade, with a copy of the system proposed to be adopted by the electric light company under the provisional order, was read, and the borough surveyor reported thereon, stating that the system proposed was satisfactory, subject to the iron pipes containing the mains being provided with a sufficient number of service boxes. It was resolved that the report be adopted and forwarded to the Board of Trade.

Cantor Lectures.—The first of the set of Cantor lectures on "The Electric Transmission of Power," by Gisbert Kapp, will be given on Monday, February 16, at 8 p.m. Syllabus of Lecture I.: Importance of Transmission generally; Distinction between Live Power and Stored Power; Stored Power transmitted by Electricity and Air under Pressure; Comparison between Various Ways of transmitting Stored Power; Cost of transmitting by Battery and Electromotor; Application to Tramcars.

Dover.—At the meeting of the Dover Town Council, the town clerk reported that he had, by the request of the Finance Committee, written to the Local Government Board, asking if they could defer the loan for the preliminary expenses connected with the electric light until the loan for the works was asked for, and their reply was that it must not go beyond the financial year. It was ordered, therefore, that application should be at once made for permission to borrow £550 for the preliminary expenses.

Leamington.—A special meeting of the Corporation was held on Tuesday, for the purpose of taking steps to apply for a provisional order for the supply of the electric light for public and private purposes. Mr. J. Hinks, mayor, presided. The Council decided to apply under the Electric Lighting Act for a provisional order, and that the consent of the Corporation be not given to the application of the Midland Electric Lighting Company for a provisional order, but that the town clerk be instructed strenuously to oppose such application.

Oil Engine.—A new petroleum motor is described in this week's *Electricité*, designed by M. Daimler, and made by MM. Panhard et Levassor, of Paris. The sizes now made are from ½ h.p. (700 revolutions) up to 5 h.p. (550 revolutions), the latter type being with four cylinders. The fuel consumption is low, one pint of petroleum per horse-power hour. The larger type, 5 h.p., goes into small space, 2ft. 6in. by 1ft. 9in., and 3ft. high. It is well made, and has been applied with much success to driving dynamos for small private installations.

Bradford.—At the meeting of the Leeds Gas Committee Alderman F. Priestman, in referring to electric supply, said he thought the Corporation had taken the proper course in having an installation of electricity, instead of allowing private companies to get the power to compete with the gas works and eventually render it necessary for the Corporation to buy them out. It was unkind of Leeds aldermen to point to the action of Bradford as an instance of failure, for quite recently deputations from other towns had visited Bradford and expressed gratification with what they had seen.

Accrington.—At the Accrington Town Council the town clerk read a letter from the Accrington and Church Co-operative Society urging the Corporation to take into consideration the early introduction of electric lighting into the borough. It was resolved that the town clerk write to the society and ask them if they were prepared to take a supply of electricity for lighting up all their shops and premises within the borough at such price, not exceeding the maximum allowed by the provisional order, as the Corporation may supply it at after the establishment of their works.

The Trans-Pacific Cable.—The Hon. Audley Coates, a member of the Legislative Council of Sydney, writes to Sir John Macdonald, the Candian Premier, in reference to the Trans-Pacific cable, proposing a conference of Canadian and Australian delegates, to be held in May next. Mr. Coates says that three Governments will guarantee to share any loss that may occur, and that Hawaii and Fiji will each give £5,000 a year for 15 years. The projected route of the cable is from Vancouver to Hawaii, Samoa, Fiji, and Queensland. The cost is estimated at £2,000,000, and the guarantee is expected to extend to about £750,000 per annum.

Guernsey.—The Guernsey Railway Company, Limited, having obtained the necessary authority for the use of electricity as a motive power on the parallel system by means of an overhead conductor, the directors are prepared to consider proposals from firms willing to carry out the required alterations, including the supply of the electrical plant. The line may be inspected by appointment with Mr. William Gumbley, secretary and manager, 35, High-street, Guernsey, from whom any further information may be obtained, and to whom proposals should be addressed so as to reach him by 28th inst.

Utilising Tidal Power.—At the last meeting of the Yorkshire College Engineering Society, a discussion took place on "The Utilisation of Tidal Power." The subject was started by Mr. W. H. Drake, and Prof. Goodman took part in the discussion. The resultant opinion was that the power available from this source has been considerably over-estimated. The greatest possible advantage derivable from each acre of water 10ft. deep, reckoning a working day at eight hours, was stated to be 3¾ h.p. It was considered of more importance to economise the present wasteful consumption of coal by improved appliances and greater care.

Gatling Guns Fitted with Motors.—The Ordnance Bureau of the U.S. Navy Department has made a series of exhaustive trials at the Annapolis proving ground of the method of firing Gatling guns by electricity. The electrical apparatus substitutes for the man at the crank a small Crocker-Wheeler motor, by which the gun is fired at any desired speed up to 1,200 shots per minute, requiring only one man to direct the fire. The motor is attached to the breech of the gun and can be instantly detached if injured by a shot, and the crank can be used. As a result of these trials it has been decided to have the motors fitted to all Gatling guns on shipboard.

London County Council.—The sanction of the London County Council has been given to the works of the Notting Hill Electric Lighting Company, subject to conditions that the stone cover to the culvert shall be 2in. thick, and when crossing the roadway that 9in. of cement concrete shall be laid in addition. Also of the Westminster Electric Supply Corporation, with the conditions that the mains shall be laid under the footpath where practicable, and the boxes shall be of iron filled in with paving material. Also with reference to the Electricity Supply Corporation (Gatti), that four days' notice of intended service from distributing mains be sufficient instead of one month as heretofore.

Bath.—The Electric Lighting Committee of Bath having engaged Prof. Forbes, at a fee of fifty guineas, to make a thorough inspection and report for the Town Council upon the works at Bath, a meeting was arranged last week at the city surveyor's offices. At the same time, Mr. Massingham is having a most minute investigation made by Major-General Webber, R.E., who commenced his inspection about three weeks ago, but was unable to continue it owing to other engagements. This survey has been resumed this week. General Webber is thoroughly testing all the machinery to see that it is according to specification, and makes a separate inspection of each boiler, engine, dynamo, and circuit.

Electricity for Agriculture.—M. Camille Gonzy, the proprietor of numerous small farms in the commune of Millas (Western Pyrenees), having an area altogether of nearly 1,500 acres, has for some time past been utilising a neighbouring stream for electric lighting purposes. He has now applied electric power to the working of a wine-crushing plant. Besides providing the power for lifting and driving purposes, electricity is made to work the pumps for irrigating the vines. The 180 16-c.p. lamps employed are distributed over all the farms, and the area which they cover may be judged from the fact that the length of telephone wire connecting the buildings is 62 miles.

Coventry.—A special meeting of the City Council was held on Tuesday afternoon, when Alderman Tomson (deputy mayor), who presided, moved that application be made to the Board of Trade for a provisional order under the Electric Lighting Acts, authorising the Corporation to erect and maintain electric lines and works, and produce, store, supply, and distribute electricity for public and private purposes within the city. Mr. Andrews (chairman of the Gas Committee) seconded the resolution, and Mr Loudon, in supporting it, said that up to the present it was the experience of other towns where electric lighting had been adopted, that there was no perceptible falling off in the consumption of gas. The resolution was adopted.

French Telephones.—Before the Glasgow Philosophical Society last week, Mr. A. Erskine Muirhead exhibited and described the latest form of French telephones, including such as are specially adapted for railway signal cabins, steamers, and mines, or for military or other temporary purposes. The demonstrator explained that though the French telephones were new to the public of this country, they had been before the telephone experts of Europe for a decade. Mr. Muirhead alluded to the exchange system, and specially dwelt upon the defects in the present connecting and disconnecting system, which required great improvement. He concluded with an allusion to the batteries in use, and exhibited a new dry cell, made in Paris, and handy for steamers or railway carriages.

Ferranti Mains.—The workmen have been busy for the last few weeks along the railway line from Charing Cross to Deptford in completing the four sets of Ferranti mains, of which two only had been previously finished. For some time past, during the alterations and installation of the sub-distributing stations, current has been transmitted at full pressure of 10,000 volts from Deptford to London and back, the load being taken off again at Deptford. Not a single fault resulting from the high pressure has yet been found, though difficulty was met with in the first laying, to find a fault of blank want of continuity in the underground main—a problem it will be felt by electricians, on a little reflection, to be a very peculiar one, when combined with absolutely good insulation, to readily find out by any ordinary means of testing.

High Tension for Frankfort.—The Oerlikon Company have recently carried out some experiments with reference to their proposed intention of transmitting 300 h.p. to the Frankfort Exhibition from Lauffen-on-Neckar, a distance of over 100 miles, in conjunction with the Allgemeine Gesellschaft of Berlin. The experiments were carried out over a line a mile long with pressure increased gradually, commencing at 1,500 volts and rising to 33,000 volts. Transformers were inserted at one end of the line to transform upwards and other transformers at the further end to retransform downward. The result of these experiments, when they have had accorded to them such a practical shape as that proposed, if consistently successful, could not but prove extremely important as the starting point of many attempts of transmission of power at these enormous voltages.

New Book.—We have received a copy of "An Explanation of the Phonopore, and the Simplex Phonopore Telegraph," by C. Langdon-Davies, with reports on the Phonopore system by Mr. Latimer Clark, Prof. Silvanus Thompson, Mr. Conrad Cooke, and others. It is printed both in French and English in parallel columns. The author says that in this book there is no attempt to advance or discuss theories, results only being described, and the means by which they have been obtained. It is the answer to the enquiries of nearly a thousand correspondents who have asked for information, and is intended to enable others to understand what has been done. The phonopore, as probably many of our readers know, is the outcome of an endeavour on the part of Mr. Langdon-Davies to utilise induction effects which, in the telephone, are so objectionable.

Jamaica Exhibition.—The exhibition at Jamaica was formally opened on January 27th by Prince George of Wales. The exhibition has been arranged under the general management of Mr. S. Lee Bapty. The exhibition grounds are situated at the north of the city of Kingston upon the race track. It is a charming spot, about a mile and a half from the harbour, covering over 23 acres, and flanked by the Blue Mountains. Along the roof and sides of the exhibition building red and yellow electric lights alternate, while within electric lights of red, yellow, and blue add to the beauty of the somewhat Oriental scene. The gardens around the building are beautifully laid out with pretty walks. The English display, next to the native exhibit, is the largest and most successful. All Kingston was *en fête* for the occasion, the public buildings being decorated with flags and flowers.

Electrically-Heated Printing Plates.—A novel and promising field for electric heaters has been tried in the Government printing and engraving office at Washington. The heaters invented by Dr. Leigh Burton, of Richmond, Virginia, are used instead of gas stoves for warming the plates for printing the bank notes, and apparently with much success. The plates have first to be warmed, when the ink is rubbed into the design after the manner of printing business cards. The ink is then cleaned off when the face of the plate is hot, and the impression taken. The objections to the employment of gas stoves as hitherto used are numerous, and the ease and cleanliness of the electric heater commend itself for extensive use in such work. In order that the attendants shall not be called upon to manipulate unaccustomed forms, the electric heaters are made to fit into the spaces occupied by the gas stoves.

Electric Tramways for Burton.—A largely attended meeting has been held in Burton to consider the application to introduce electric tramways into the borough. Mr. Slater, solicitor, of Darlaston, and Mr. E. Pritchard, C.E., of Birmingham, explained the details of the scheme for the promoters, and showed that there were no difficulties in the way of the construction or working of the line which could not be overcome. It was also pointed out that the Corporation, by the General Tramways Act, were thoroughly protected against loss, and that they were empowered to supervise the work and regulate the traffic. It was stated, however, that the Corporation could not work the line themselves except by obtaining a special Act of Parliament. A resolution approving of the proposal was unanimously carried, and it was also decided to appoint a deputation to wait upon the Council and inform them of the feeling of the meeting.

City of London Pioneer Company.—As mentioned in our article last week, a company entitled The City of London Electric Lighting (Pioneer) Company, Limited, was brought out on Monday with a capital of £100,000 in £50 shares, to take up and work the contracts for the lighting of the City. The board of directors is: The Right Honourable Alderman Joseph Savory, Lord Mayor of London, chairman; His Grace the Duke of Marlborough, chairman of the Electric and General Investment Company, Limited; the Right Honourable the Earl of Suffolk and Berkshire, Charlton Hall, Malmesbury; the Honourable Alan Charteris, 23, St. James's-place, S.W., and Lloyd's, E.C.; J. Bevan Braithwaite, jun., Esq., director of the Electric and General Investment Company, Limited. Consulting engineer: Major-General C. E. Webber, C.B. J. Cecil Bull, Esq., secretary. Offices, 1 and 2, Great Winchester-street, E.C. We believe the capital was considerably over-subscribed, and there is a whisper that shares are already at a considerable premium.

Bibliotheca Polytechnica.—It is sometimes necessary for professional engineers to turn up at once the best authorities on certain subjects, whether in English or in foreign languages. A work embodying much industry and research has been published, entitled "Bibliotheca Polytechnica, a Directory of Technical Literature," being a classified catalogue of all books, annuals, and journals published in England, America, France, and Germany, including their relation to legislation, hygiene, and daily life. Edited by Fritz von Szczepanski. (London: Sampson Low, Marston, and Co.; price 2s.) The catchwords are given in three languages (English, French, and German), so that readers of every nationality can at once turn to the branch he seeks in the literature of the latest investigations. An exhaustive enumeration of the technical journals in the three great languages of the world is also given. We should imagine the book will prove exceedingly useful, and as there is a promise of an annual issue, the information will be constantly kept up to date.

Electric Treatment of Wine.—In the Paris Exhibition M. de Meritens, of the firm of early dynamo fame, showed a process of ripening wine which seems to be attracting attention in practical circles, and may possibly be adopted in the treatment of wines for use. It is a question of the destruction of the microbes of ferment. In sending a continuous current through a liquid the microbes would certainly be destroyed, but some of the liquid—wine in this case—would be dissociated into gas and its bouquet is destroyed. By the use of alternate currents M. de Meritens obviates any disadvantages in the employment of electric currents and yet destroys the microbes. In this process the wine is allowed to percolate through tubes in which are fitted silver-plated diaphragms with numerous holes punched therein, alternate discs having their holes punched in a different patterns to ensure a movement of the liquid passing. Alternate sets of the plates are connected together in parallel, and alternate currents of low potential are passed while the wine circulates through the tubes. Specimens of the plates were given to us when at the Paris Exhibition and the process exhibited in action, but its usefulness for Britain is naturally very limited.

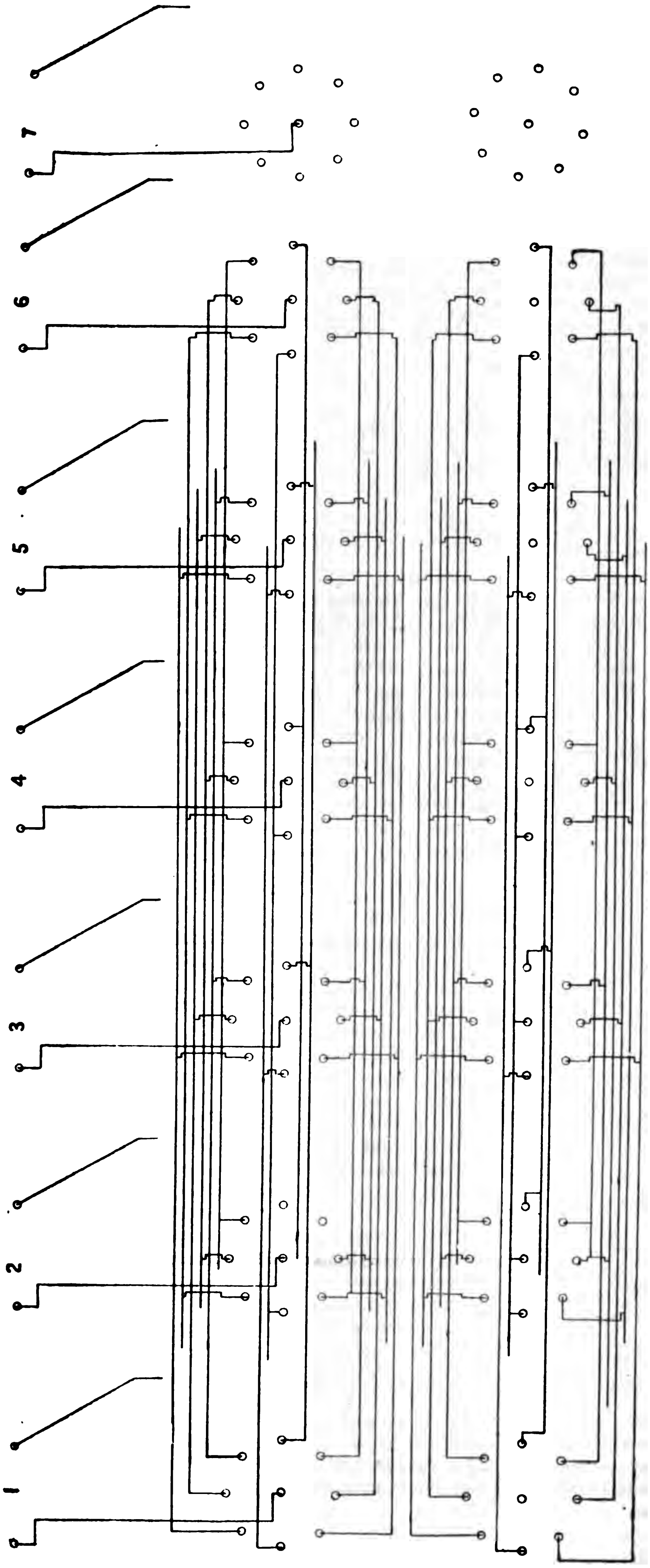
The Liverpool Overhead Railway.—The half-yearly meeting of the Liverpool Overhead Railway Company shareholders was held at Liverpool on Tuesday. Sir W. B. Forward, chairman, explained that the delay in construction had taken place mainly through the non-delivery of material. The progress now, however, was fairly rapid. The line, which is to be 5½ miles in length, along the dock line, is complete for one mile, from its northern extremity, and foundations have been laid to the centre of the city. It was hoped the northern section would be at work by October. Electricity was proposed as a motive power, and tenders from four engineering firms were to be in by the end of the present month, being both for equipping the railway and working it. Quoting from American experience, he showed the probable enormous growth of the traffic on the line, and anticipated no difficulty in paying a good dividend. Further calls of £1 per share would be made in April and July. The report and accounts were adopted, and the retiring directors were re-elected. The chairman, replying to a vote of thanks, expressed the opinion that not many years hence the Liverpool Overhead Railway would be looked upon as the best railway property in Lancashire.

Life of Incandescent Lamps.—We are in receipt of a new American technical journal, *Electrical Enterprise*, published in Boston. In one of the first numbers we notice the following sensible remarks upon the life of incandescent lamps as affected by the means of producing the vacuum: "In the processes of manufacturing incandescent lamps there are as many devices, secrets, kinds, and methods as there are varieties of lamps. In one particular they all agree, and that is in heating the carbon filament during exhaustion. That in this portion of the process, so necessary to the production of the perfect lamp, there may be conditions whereby the filament can be injured, has recently been brought to the attention of electricians by the development of mechanical quick-acting air pumps. With these a fairly good vacuum was obtained in a few minutes, and then the current was turned on to expel the air and the exhaustion continued. These lamps showed both higher efficiency and longer life than other lamps made from similar filaments, but exhausted in the usual way, where possibly not nearly as good a vacuum had been obtained by the mercury pump when the current was turned on. The filaments in the latter case were possibly partially consumed and disintegrated in the rarefied atmosphere. It is a question well worthy of study, whether lamps as manufactured in quantities to-day are not injured by heating the filaments to incandescence before nearly all the air has been removed."

Secondary Batteries.—Dr. J. H. Gladstone and Mr. Hibbert have been experimenting on the effect of adding sodium sulphate to secondary batteries, and have communicated the results to the *Phil. Mag.* [5], 30. We take the following condensed account of the experiments from the "Abstracts" in the January number of the Chemical Society's *Journal*: "The addition of sodium sulphate to the acid solution of an ordinary secondary battery is known to be of considerable advantage to the working of the cell. The authors find that in this case a large proportion of sodium sulphate is formed in close contact with the lead sulphate at the cathode, and they show that this would be favourable to the reduction of the latter substance, as a paste made of equal parts of red lead and lead sulphate is more readily reduced in a solution of normal sodium sulphate than in dilute sulphuric acid. They find also that the presence of sodium sulphate diminishes the local action arising between the acid and different parts of the plates. No indication could be found of the formation of either of Frankland's sub-sulphates of lead on treating litharge with dilute sulphuric acid, and the authors believe the ordinary sulphate of lead to be the substance produced in the voltaic reaction. The high initial E.M.F. observed in a secondary battery when the charging current has just been stopped is shown to be due to inequalities in the acid strength produced by the current. An increase in the strength of the acid surrounding the positive (peroxide) plate is found to take place, and this causes the abnormal E.M.F., which gradually disappears as the strength of the acid is equalised by diffusion."

International Niagara Commission.—The Cataract Construction Company, having invited various firms to send in projects for the utilisation of about 125,000 h.p. at Niagara, and its distribution, partly to an industrial district in the neighbourhood of the Falls, and partly to the town of Buffalo, appointed an international commission to adjudicate on the plans sent in. This commission consisted of Sir William Thomson, F.R.S., president; Dr. Coleman Sellers, Professor of Engineering Practice at the Stevens' Institute of Technology, Hoboken, N.J.; Prof. E. Mascart, Membre de l'Institut, Paris, and Directeur du Bureau Central Météorologique; Colonel Th. Turrettini, Directeur des Travaux d'Utilisation des Forces Motrices du Rhone à Genève. After a careful examination of a large number of projects sent in, in accordance with the letter of invitation of the Cataract Company, the commission have awarded the following prizes—Projects combining the development of power and its distribution. First prize: Not awarded. One second prize: To the scheme of Messrs. Faesch and Piccard, Geneva, and Messrs. Cuenod, Sautter, and Co., Geneva. Four third prizes: To the projects of Mr. A. Hillairet and Mr. Bouvier, Paris; Mr. Victor Popp, Paris, and Prof. Riedler, Berlin; Prof. L. Tigreux and Mr. L. Levy, Paris; the Pelton Water Wheel Company, San Francisco, Cal., and Norwalk Iron Works Company, S. Norwalk, Conn. Projects for the hydraulic development of the power—First prize: To the project of Messrs. Escher Wyss and Co., Zurich. Two second prizes: To the projects of Messrs. Ganz and Co., Budapest; Prof. A. Lupton, Leeds, and Mr. J. Sturgeon. Projects for the distribution of the power: No prize awarded.

Ipswich.—At the last meeting of the Ipswich Lighting Committee a letter from the Ipswich Electricity Supply Company to the Mayor asking for reconsideration of their demands, which were originally recommended for consent in conjunction with Messrs. Laurence, Scott, and Co., but which, owing it was maintained to misstatements, the Council had set aside. The Mayor said he did not like bringing up a thing that was settled, but he thought this company had been hardly dealt with. In the course of a further conversation the vice-chairman demurred to bringing the matter up again, and Mr. Brand argued that it would be wrong to have more than one company in operation; and further, that it would always be open to the Corporation, if they chose, to go for an order for power themselves to light the streets with electricity. Eventually, the Mayor said he should confer with the town clerk as to placing the notice on the agenda paper for the Council meeting, and the town clerk intimated that he should advise a notice to read the letter and consent to the order if thought advisable. The town clerk next read a letter from the Board of Trade enclosing a copy of a letter from the agent to the promoters of the order applied for by Laurence and Scott, Limited. The promoters agreed to make the alterations desired in the first resolution passed by the Town Council on January 7, those being the conditions on which the consent of the Corporation was given. As to the other resolutions: that the committee secure such a modification of the draft order as would give the Urban Sanitary Authority power to acquire the undertaking after 10 years instead of 42 years, and making the dividends vary in inverse ratio to the rates charged, the promoters did not see their way to agree to either proposition. Mr. Brand hoped someone would give them the electric light before long. He did not care who it was. The town clerk said he had seen the officials of the Board of Trade on the subject, and was told by them that the course pursued by the Board was to get the promoters and the Sanitary Authority to agree between themselves whenever they could, and it was added that if they did not agree the Board would deal with it very shortly, as their minds were made up. In the end it was agreed to report that the letter had been received, and that in the opinion of the committee it was not desirable to go to any expense in the matter.



POST OFFICE INSTALLATION. FIG. 5.—Connections of Dynamo Switches.

POST OFFICE INSTALLATION.

We herewith continue the illustrations of the details of this installation, and shall in our next issue consider the work as a whole.

Fig. 5 shows the connections of the dynamo switches, and Fig. 6 shows details of the fuse-chamber board.

Fig. 7 shows the elevation of the fuse-board one-eighth full size. The details (Fig. 6) are one half full size.

Fig. 8 shows the interchangeable dynamo switch one-quarter full size.

ELECTROLYSIS OF SILVER SALTS.

BY ALEXANDER WATT.

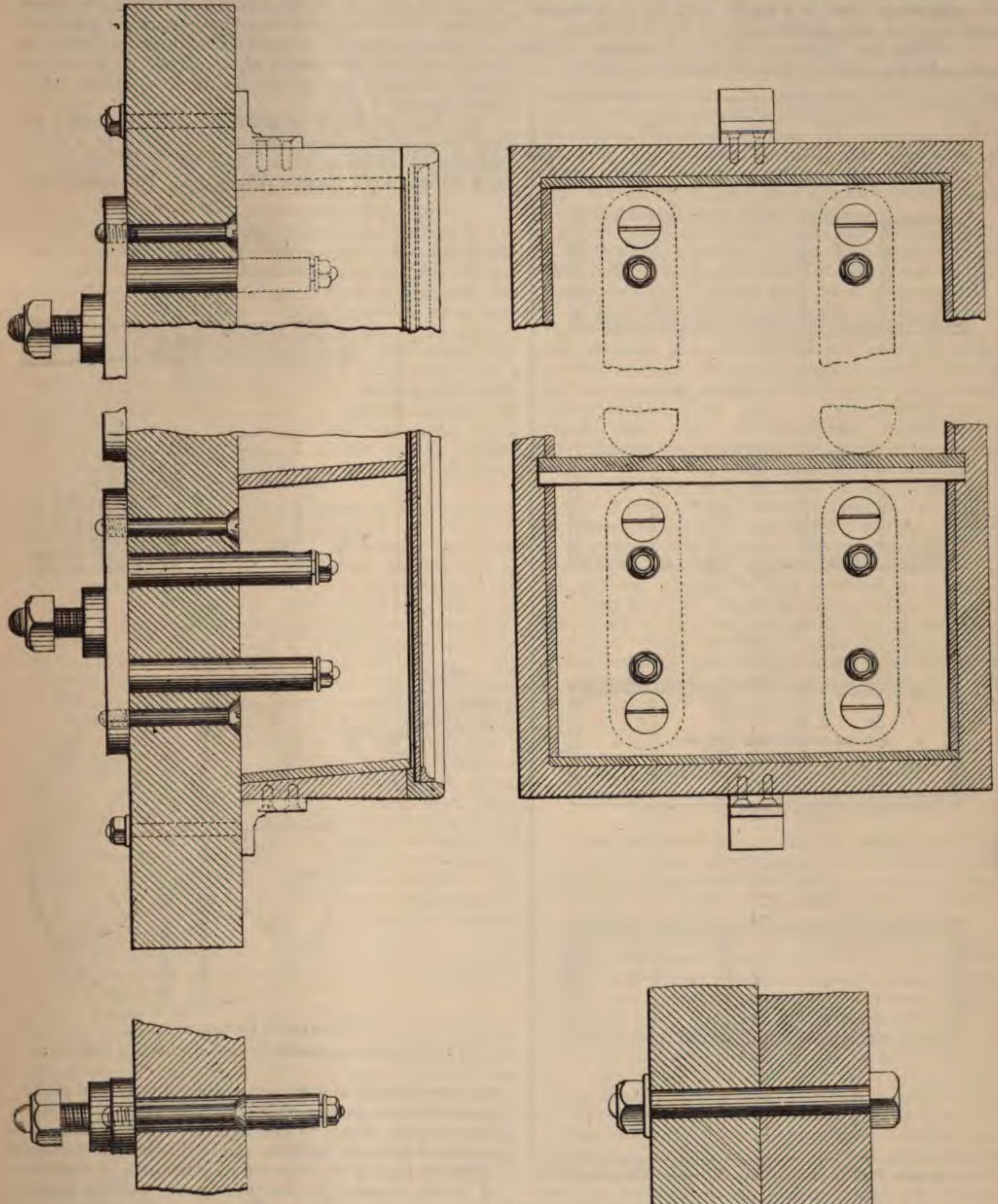
(Continued from page 7.)

In the following, and some subsequent experiments, an endeavour was made to determine whether it would be possible to obtain a satisfactory electrolyte from what may be termed *acid* solutions, in contradistinction to the ordinary alkaline solutions used in electro-plating, which could be useful for some purposes in the electrodeposition of silver. Well knowing the difficulties which usually present themselves when dealing with such solutions electrolytically, the subject was not approached without considerable misgivings. Having been successful, however, in depositing alloys of metals from mixed solutions of non-alkaline metallic salts, the writer indulged a faint hope that possibly a few trials in the direction indicated might lead to more or less favourable results.

13. *Sulphate of Silver.*—A solution of this salt was prepared by digesting moist carbonate of silver in a moderately strong solution of sulphuric acid, and the resulting solution was afterwards diluted with water, the proportions of acid and water being 500 parts of the latter to each five parts of the former. The solution thus prepared was then tried with the current from a single Daniell cell, a clean brass plate being used as the cathode, when, in a few moments after immersion, the plate received a film of a golden-yellow colour, the deposit gradually becoming grey and of a granular character, the particles of which fell from the plate when it was gently moved in the bath. When the plate had been immersed for about 10 minutes or so, spongy metal commenced to form at its lower corners. A further addition of water was then made to the solution, and a newly prepared plate immersed, but even in this very weak solution the metal still refused to deposit in the reguline form, with the exception of a thin film of white metal, which in each case was found attached to the plate after the non-reguline deposits had been removed. A solution of the sulphate was next prepared by double decomposition, from mixed solutions of

nitrate of silver and sulphate of soda, and the resulting precipitate of sulphate of silver then treated with water until a saturated (though weak) solution of the sulphate was obtained, which was then electrolysed as before with the current from one cell. In this case, as in the preceding, the brass plate became promptly coated with a golden-yellow film, and there was no disposition whatever (except a very slight film of white metal adhering to the brass) for the metal to deposit in a reguline condition.

14. *Sulphate of Silver by Electrolysis.*—It was next determined to ascertain the behaviour of silver sulphate when prepared by electrolysis, by which the varying degrees of acidity of the bath could be noted, and their effects upon the character of the deposit more closely observed. For this purpose a solution of sulphuric acid was prepared by adding five parts of the acid to each 500 parts of the water used. A silver anode, and brass plate for cathode being placed in this liquid, the current from two Daniells was allowed to pass, when, in a few seconds after, the brass plate gradually assumed the golden-yellow colour, indicating the presence of silver in the solution, and in about a quarter of an hour or so a spongy deposit of silver was found to have formed at each of the lower corners of the plate. When this loose form of metal was rubbed off the plate with the finger, a slight film of white silver as before was found beneath, and which adhered firmly to the brass surface of the cathode.

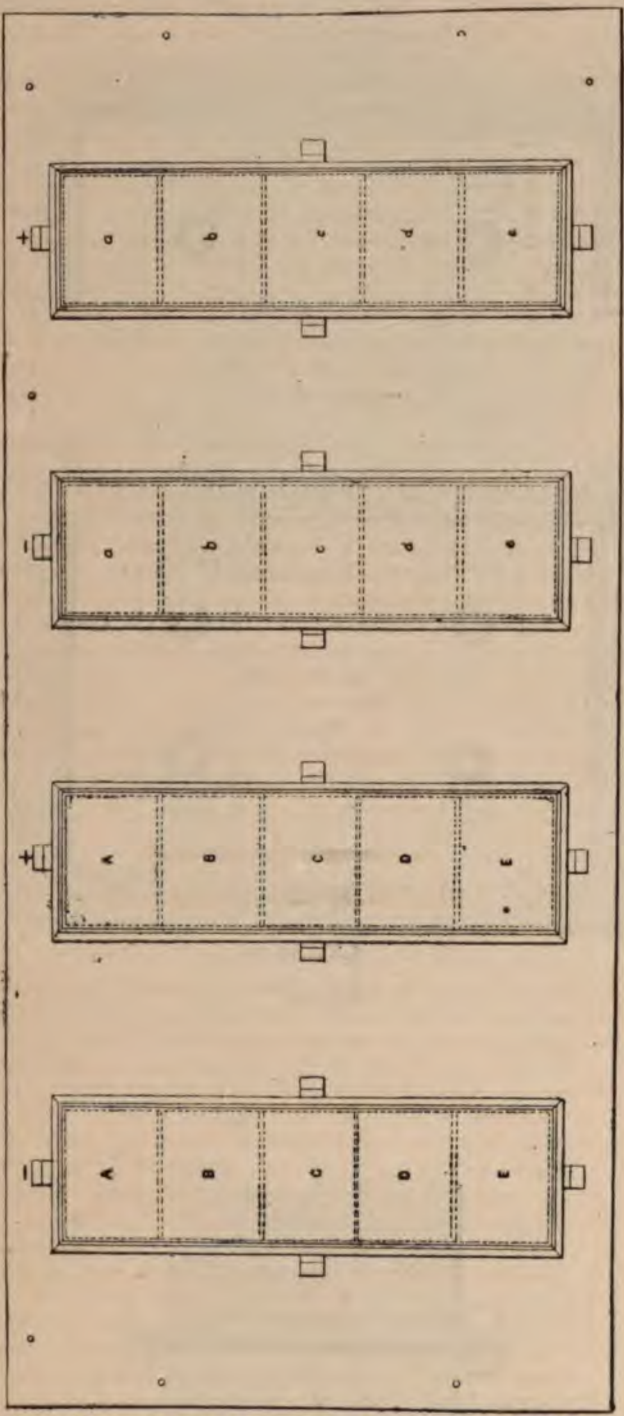


POST OFFICE INSTALLATION. FIG. 6.—Fuse Chamber Board. Details.

15. *Sulphates of Silver and Alumina, Etc.*—It was now resolved to ascertain if the addition of other sulphates, from which their metals are not reducible by electrolysis,

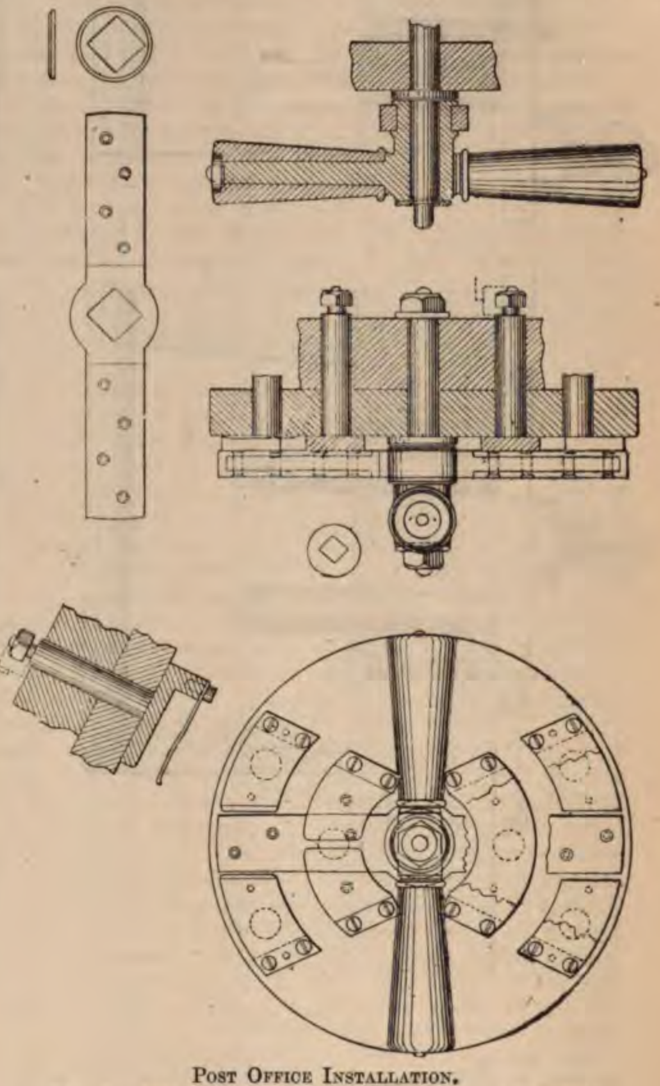
would have a tendency to check the formation of non-reguline silver upon the cathode. With this end in view, a solution of sulphate of alumina was first added to one of sulphate of silver, and the compound liquid then tried with the current from a single Daniell cell, but it was found that the silver still refused to deposit in a proper condition. Sulphate of magnesia, ammonia, and bisulphate of potassa were afterwards tried in a similar way, but no favourable results followed these modifications of the electrolyte.

16. *Sulphate and Nitrate of Silver.*—A solution of the mixed salts was obtained electrolytically, as follows: An acid solution was formed of nitric acid five parts, and water 500 parts; in this was immersed a silver anode connected to a single Daniell and a brass cathode, when in a very few seconds a black film formed on the brass surface, which, on being rubbed off the plate, exposed a slight film of silver attached to the brass. To the above solution was next added a weak solution of sulphuric acid (five in 500 parts), and the mixed solution was then tried with the same current, when it was found that a grey deposit of silver quickly formed, but, excepting the slight film of reguline metal before noticed, the metal, which deposited with considerable rapidity, persistently assumed the spongy character, and when the plate had been left undisturbed for about half an hour a mass of spongy metal was found at the bottom of the vessel, which nearly approached the anode. The solution was next diluted with about 250 parts of water, when a fresh plate became coated with a yellow film immediately after immersion. A similar addition of water was again made, the anode surface reduced, and a long thin iron wire interposed in the circuit, under which conditions, although the same yellow deposit reappeared, it was found to be firmly adherent, whereas all the previous deposits of a like character were easily wiped off the plate with the finger. Beneath the yellow film, as before, there was a white deposit of silver.



Post Office Installation. Fig. 7.—Fuse Chamber Board.

17. *Ammonio-Nitrate of Silver.*—A solution of this salt was prepared by adding ammonia in excess to a strong solution of nitrate of silver, until the oxide of silver at first thrown down became redissolved. This solution was then considerably diluted with water and the liquid electrolysed with the current from one cell, when it was found that metallic silver, in the form of a fine powder, was deposited upon the cathode, and readily became dislodged when the plate was gently moved in the bath. An addition of nitrate of ammonia was next given and the solution further diluted, but no modification of the solution or of the current induced the metal to assume the reguline condition beyond a mere film which attached itself to, but did not alloy with, the brass plate.



Post Office Installation.
Fig. 8.—Interchangeable Dynamo Switch. ¼ Full Size.

18. *Ammonio-Sulphate of Silver.*—A bath was formed by adding recently precipitated and moist sulphate of silver to a warm solution of ammonia (one part ammonia to two parts water), the mixture being repeatedly agitated for a few minutes. The clear liquid being decanted from the undissolved sulphate was then diluted with water, and the solution electrolysed with the current from one Daniell. The deposition from this solution was pretty quick, but the

silver was of a rather dark colour, and after a short immersion of the plate it was found that a film of an uniform brown colour had deposited upon the first layer of reguline metal, and when the plate was gently rubbed the brown film readily came away, exposing a film of white metal on the brass surface. Even when this solution was considerably diluted, the deposited metal, at first bright and reguline, gradually became coated with a brown, and, indeed, almost black film, which was especially dark in colour at the lower corners of the plate.

19. *Ammonio-Chloride of Silver.*—A solution of this salt was prepared by dissolving moist chloride of silver in strong liquid ammonia, the solution being afterwards diluted with water. With the current from two cells, metallic silver, in a spongy form, was deposited upon the negative plate, and the metal gradually assumed a bright crystalline appearance at the extreme edges of the spongy metal. No modification of the solution or of the current could induce the metal to assume the reguline form.

20. *Chlorides of Silver and Ammonium.*—To form a bath of this combination moist chloride of silver was dissolved in a strong solution of salammoniac, and the solution was afterwards diluted with water. When electrolysed with the current from two cells, a white deposit of silver soon formed upon the brass plate, but a short time after it was found that the electrolytic action had ceased. On examining the anode it was found to be covered with a firmly adherent film of a dark colour, which was with difficulty dislodged from the plate. A portion of this film, after being washed, was treated with nitric acid, which produced no effect upon it. A further portion, treated with strong ammonia, became dissolved; the salt, therefore, was probably a subchloride of silver.

21. *Chlorides of Silver and Ammonium by Electrolysis.*—A moderately strong solution of salammoniac was first prepared, in which was then placed a silver anode and brass cathode, as before, and the current from two Daniells in series passed through the liquid. In about four or five minutes a white deposit of silver formed upon the brass surface, but, as in the last case, the anode soon became iridescent, then blackened, and in a few minutes after the current stopped. Liquid ammonia was then added to the solution, and the anode cleaned, when white metal again deposited upon the cathode; a few minutes after, however, the current again stopped, and the anode once more appeared coated with the film of subchloride.

21. *Phosphate of Silver.*—A solution of this salt was prepared by dissolving moist carbonate of silver in a strong solution of phosphoric acid. The solution, after being moderately diluted with water, was electrolysed with the current from one cell, when a somewhat iridescent film quickly formed upon the brass plate, the deposit eventually exhibiting brown patches on both sides of the plate. On rubbing the plate with the finger the brown deposit readily became dislodged, when a film of white metal, as so often noticed before, appeared on the surface beneath. A good reguline deposit, however, could not be obtained from this solution by any subsequent modification of the strength of the bath or of the current.

22. *Mucate of Silver.*—A bath of this salt was prepared by digesting moist carbonate of silver in a strong solution of mucic acid. With the current from one cell only a slight patchy film of silver appeared on a freshly-cleaned brass plate. A second cell being introduced, deposition was much quicker, but it was soon found that the white metal at first deposited was succeeded by the brown variety of the metal. This solution was a rather poor conductor, and whether used in its more concentrated form or diluted, it failed to yield a fair deposit of reguline metal.

23. *Permanganate of Silver.*—To form a bath of this salt, a solution of nitrate of silver was added to one of permanganate of potassa, and the crystalline salt which subsequently formed was then dissolved in water, and electrolysed with the current from two Daniells, when an iridescent film at once formed on the cathode, which on being removed exposed a film of white metal beneath, but beyond this no satisfactory result could be obtained.

24. *Sulphocyanides of Silver and Potassium.*—A solution was prepared by dissolving carbonate of silver in a strong solution of sulphocyanide of potassium, the latter being in excess to prevent the sulphocyanide from being thrown down when the liquid was diluted with water. The diluted solution, electrolysed with the current from one cell, yielded a very quick deposit, somewhat iridescent at first, but the metal gradually became white and very bright; indeed, the deposit remained bright during about half an hour's immersion of the plate, after which period, however, it slowly became dull and of a darkish colour. The metal, however, after being scratch-brushed, presented the usual appearance of electro-deposited silver, and was very firmly adherent to the brass surface.

24. *Salicylate of Silver.*—A solution was prepared by digesting carbonate of silver in a strong warm solution of salicylic acid, in which the carbonate slowly dissolved. When cold the solution was separated from the uncombined acid and carbonate present, and after being again warmed was electrolysed with the current from two cells, when an iridescent film slowly formed upon a brass cathode, beneath which was found a grey film of silver.

It will have been noticed, in perusing the details of some of the foregoing experiments, that from many of the solutions tried the metal, after the first white film of silver had become deposited, assumed the form of a non-metallic film of a golden-yellow or brownish colour, and that this deposit was readily removed from the plate by slight rubbing. In most instances the golden-yellow film gradually darkened to a brown colour, and after a longer immersion of the plate this was generally succeeded in its turn by a deposit of spongy metal. From this it is inferred that the yellow film and its subsequent modifications of brown, more or less dark in colour, was in reality metallic silver in a highly-comminuted condition, the character of which may ultimately merge into the granular state of a grey colour, a blackish powder of non-metallic appearance, or a group of agglomerated particles of a spongy form, while in some instances, as before observed, crystals of bright silver are found to spring out from the edges of the spongy mass. It may be here remarked, in passing, that the writer has before called attention, when treating of the electrolysis of tin, lead, and some other metals, that the crystalline form of metal invariably succeeds the spongy condition provided the vessel in which the operation is conducted be allowed to remain undisturbed.

(To be continued.)

UNDERGROUND MAINS.—IV.

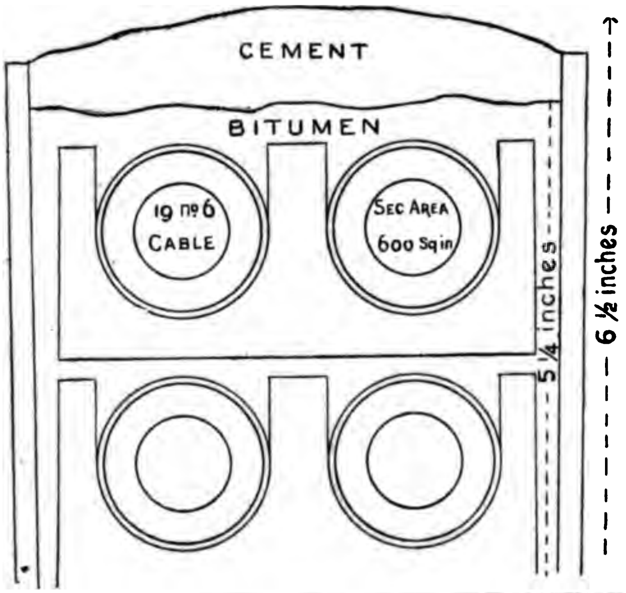
THE CALLENDER SOLID SYSTEM.

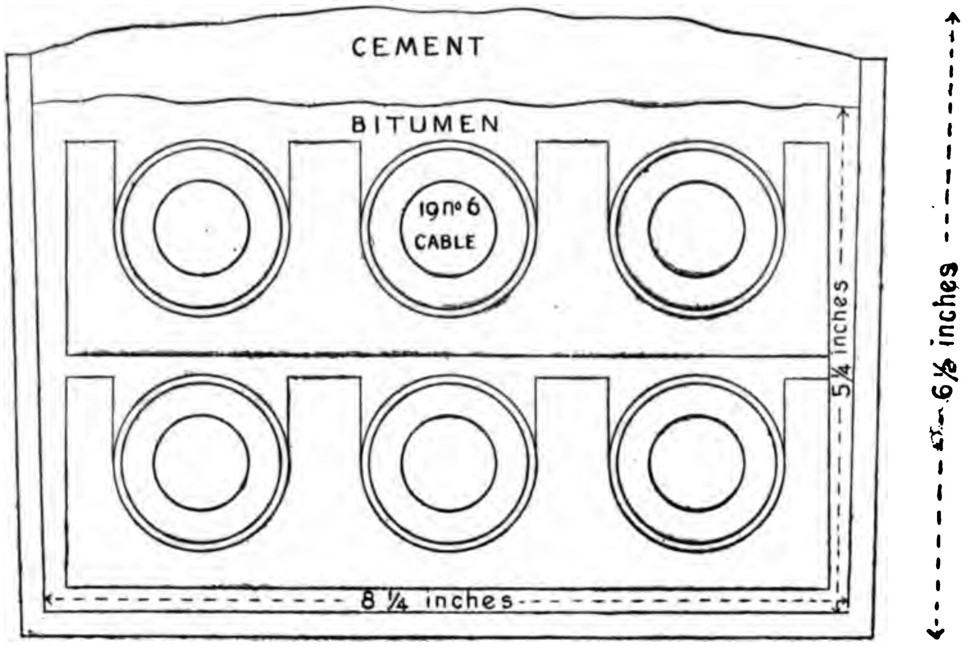
In the Callender solid system of underground electric mains, the cables, heavily insulated, are laid in suitable troughs, generally of cast iron, placed in trenches under the street, and the whole of the vacant space in the trough round the cables is run in solid with refined bitumen. All the bitumen employed is genuine natural Trinidad bitumen, free from any admixture of gas, tar, and pitch.

The whole forms a solid and compact mass, into which neither gas nor water can possibly penetrate, and which itself forms a very high electrical insulation. There are few substances more durable than this bitumen, and with cables thus embedded there is little probability of any deterioration taking place in mains when once laid, while the thorough mechanical protection which is ensured reduces to a minimum the liability of injury from exterior causes.

Mains laid on this plan are permanent, and form a sound engineering job. It is of course clear that such mains should only be laid when the conditions do not require that the capacity of the cables should be afterwards altered. The Callender solid system is especially suitable for connecting mains for isolated plants where the conditions are settled and well known; for heavy mains in large cities where the consumption is likely to attain its maximum at once; for heavy distributing networks; and for the heavy feeders which are run to various points of the system of three-wire distribution. It is also peculiarly suitable for arc lighting on the series system where long lengths of single or double mains are required to be run.

The combination of vulcanised bitumen as the insulation for the cable itself, with plain bitumen run around it as a sheath in the trough, is one that ensures an absolutely safe and constant insulation, on which faults are unlikely to appear. Repairs, when necessary, are easily and rapidly made. Altogether, it forms one of the most trustworthy and satisfactory methods of placing cables underground, and has a certainty of being more permanent and lasting than most of the other parts of an electric lighting plant. The work of laying, once done, is thorough and complete.





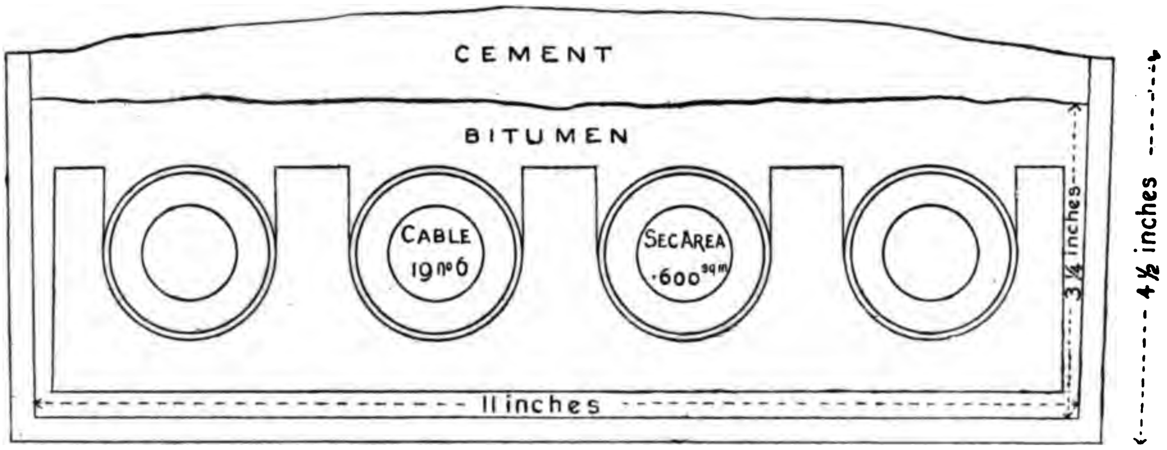


Fig. 1.—Callender Solid System of Underground Mains. Sections of 4 and 6-way mains in trough with cement cover.

The troughs for the mains are made of cast iron. For town work this is especially preferable, as it offers a permanent protection from the picks of workmen of other companies. In some cases the upper surface of the trough having been filled nearly to the level by bitumen, is covered by a layer of cement. In others the trough is covered in with cast-iron lids. The thickness of the metal is from $\frac{3}{16}$in. to $\frac{5}{16}$in., varying with the size of the trough and the liability of the soil to disturbance. These iron troughs are made in lengths of 6ft., having socket pieces cast on one end, so that when fitted together the surface inside the trough is of one level. For carrying the mains round corners, and for changing levels at crossings, circular pieces and curved troughs are made, but considerable deviation from the straight line is possible with the ordinary type.

In country roads, and in places where wood is plentiful, troughs of sound timber are often substituted for those of cast iron, care being taken to select wood which will stand underground without rotting. The planks should not be less than ¾in., and the lid should be of 1in. stuff. It is not advisable to use creosoted wood, as the action of the products of coal-tar distillation are found to be injurious to nearly every form of dielectric.

Brick and cement trenches are occasionally used for special situations, but they are expensive, and offer no advantages over those of cast iron.

The ordinary shapes and sizes of mains on the Callender solid system are shown in Fig. 1, which comprises sections of four-way and six-way insulated mains, laid in bitumen in iron troughs and covered over at the top with cement.

A very usual case in a distributing network is where a pair of heavy feeders to a distant point are run along with the distributing mains in the same trough. This arrangement is shown in Fig. 2. In both cases the position of the cables in the trough is kept by bridges of hard bitumenised wood of the shape shown, which are first thoroughly dessicated, and then saturated with bitumen. These prevent the cable from touching the bottom of the trough, or of accidentally shifting their relative positions.

In Fig. 3 is shown a pair of heavy feeders, 91 strands of No. 9 wire. These are highly insulated, and each covered with outer lead casing; then laid one above the other in solid bitumen in a narrow iron trough, and covered in with cast-iron lid. The joint of the trough is shown in section below.

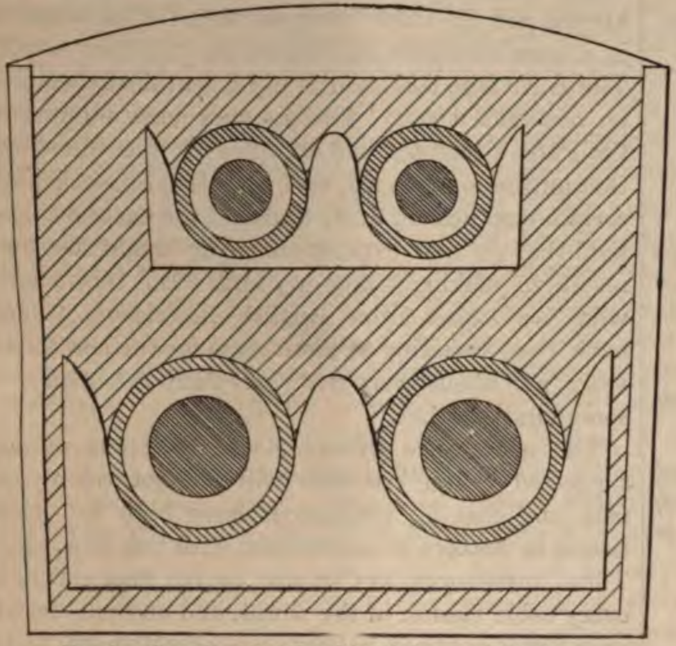


Fig. 2.—Trough containing Distributors and Feeders.

In actual practice the method of laying is as follows:

The trenches in the ground having been dug and levelled, the iron troughs are laid therein, and are jointed together in one length with countersunk bolts and nuts, Fig. 4.

Bitumen is meanwhile being heated in the cauldrons, and a little of this run along the bottom of the trough. While still molten, the bitumenised wood bridges are pressed into place across the trough at intervals of 18in. apart. When the bitumen is set, the cable, which has been brought on huge drums, is paid out into the trenches, and laid along into the spaces of the wooden bridges. The cable is then drawn taut, and melted bitumen is poured in between the cables and between the cables and the sides of the trough.

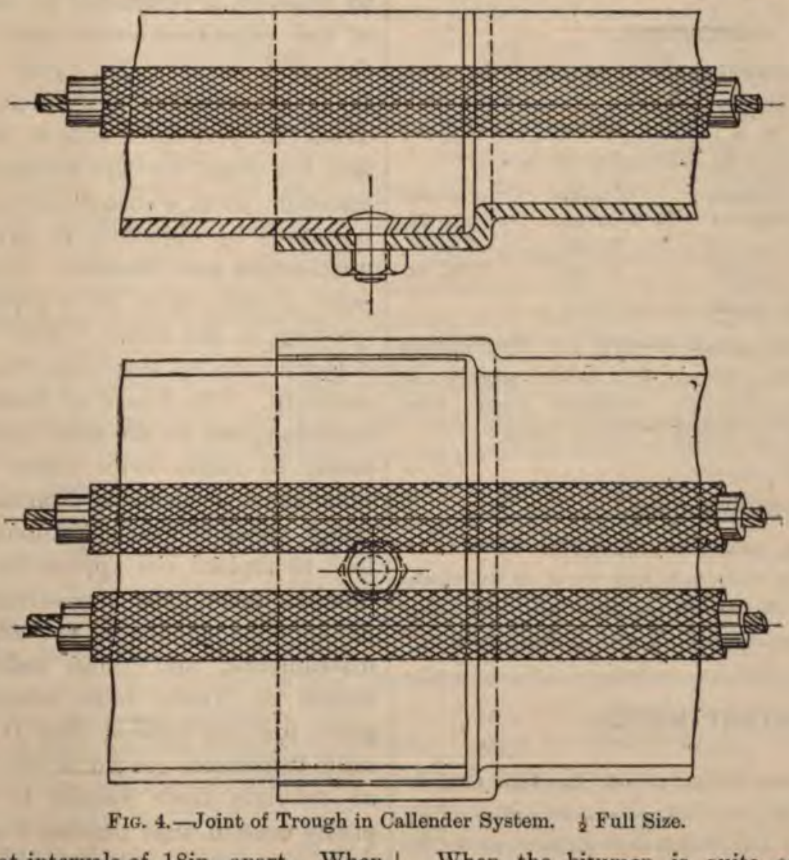


Fig. 4.—Joint of Trough in Callender System. ½ Full Size.

This is done by moving the bitumen cauldron on wheels along the trench, and by means of a large ladle, pouring a little molten bitumen in at a time. When this first layer is cool, the men come back again and pour in a little more, and so on, for about six times, thus allowing the bitumen to fill up every cavity round the cables. In the case of cables above one another, the whole process is, of course, repeated along the length. The bitumen is run in to within an inch of the top of the trough.

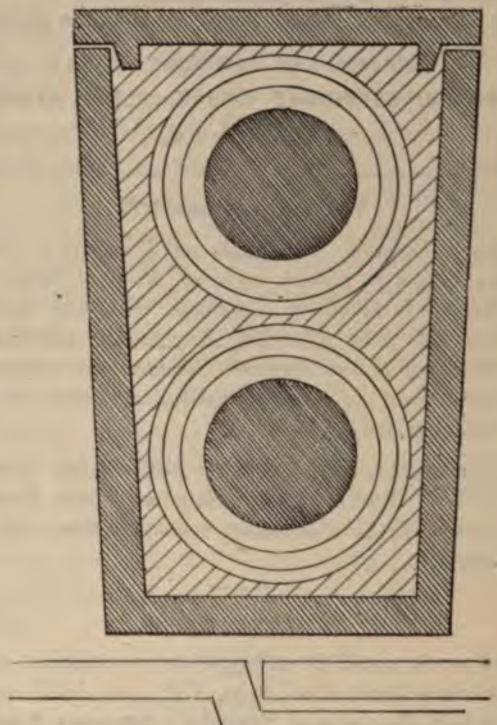


Fig. 3.—$^{91}/_{9}$ Lead Covered Cable. ½ Full Size.

When the bitumen is quite cold a layer of Portland cement from 1in. to 3in. thick, according to circumstances, is put upon the top of the bitumen, and where crossing a roadway a brickwork, cast-iron, or other protection is placed over the top, to guard against damage from heavy traffic.

(To be continued.)

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

THE BOARD OF TRADE AND STANDARDS.

As might have been expected, the report of the Standards Committee, as foreshadowed in the statement given elsewhere in our columns, will come practically to saying we authoritatively adopt the C.G.S. system and the Paris Congress ohm. This adoption is a pure formality, and leaves us "as you were." The B.A. standard ohm is not scientifically exact—no one said it was. The mercury unit adopted at the Paris Congress, and accepted by the Standards Committee, is not exact, and, what is more, we believe certain electricians, J. T. Sprague, for example, contend that no two experiments can obtain the same results in making a mercury unit. But this is only what we expect from English electricians. They have been tinkering at these units for the last thirty years, and about every five years there is a change of some kind or other.

The acceptance by the Board of Trade of any suggested "ohm" as unit will not get rid of one fact, and that is, resistances have been for years issued by makers in accordance with the B.A. ohm. These resistances are in use in the Post Office, in every cable station in the world, and any new resistance-boxes required in such offices will have to be made to agree with these old resistances. There is no logical reason why resistances in agreement with the B.A. ohm should not be generally and universally accepted. The only result of adopting another unit will be to add to the work of those who use the old units, as if there was not enough work in the world now. A man wants to measure a resistance in ohms, and he has one of the resistance-boxes made in agreement with the B.A. unit. He gets his resistance, and then, forsooth, has, if connected with the Board of Trade, to perform a sum in arithmetic, or to translate his result for the edification of a lot of ultra-scientific men, whose object is to make themselves notorious by objecting to everything "that is" as unscientific and illogical. From a purely scientific point of view, there is no objection to pursuing this question of the exact "ohm" to finality—the only objection is to the changing of the commercial standard. The Board of Trade, if it has to do with anything, has to do with commercial matters, and ought to think twice before occupying a position that must lead to complication. Will the Post Office spend a hundred thousand pounds, more or less, to replace old apparatus with new, or will its officials insist upon measurements being tabulated in two columns—those actually ascertained by the instruments, and those calculated because the Board of Trade have adopted the Paris Congress unit as against the B.A. unit? Will the cable companies get rid of all their resistance-boxes or tabulate their results in duplicate? We are pretty certain that neither the Post Office nor the cable companies will trouble themselves one iota about the new unit, but go contentedly along measuring as they have measured in past years, and ignoring the new broom. If there had not been a large number of resistances in use, or if "resistances" had come in with electric lighting, then the "legal ohm" would have been as good as any other, except it should prove somewhat difficult of duplication.

We may even go farther, and say the adoption of the new standard by the "Board of Trade" will not necessarily involve the manufacture of the new standard. The old B.A. ohm may be used, and the results translated for the edification of the Board's officials, although it would save trouble if those who have to buy new resistances were to have them in accordance with the requirements. This change to the Paris Congress unit is something like a change in railway gauge would be from the normal, say, to a 5ft. gauge. None of the older lines would change, though new lines might adopt it, and the new gauge might scientifically be the better of the two. Once more, then, our objection is not to the introduction of the Paris unit as being a more scientifically accurate unit than the B.A. unit, but to its introduction as a commercial unit, from which no earthly benefit can arise. It means simply the substitution of one "arbitrary unit" for another "arbitrary unit"; and we are further inclined to agree with those who say that the substitution should not take place, because it is not so easy to reproduce the mercury resistance as it is the B.A. resistance.

LEEDS.

"The Leeds Municipality will have a bad record when the annals of electric lighting are written." Such is the statement of a local paper, when commenting upon the vacillation and procrastination of the authorities. It would be interesting to hear the opinions of such men as Wilson Hartnell and Mr. Crompton on this subject. If we mistake not, in years gone by Messrs. Crompton were active in attempting to introduce electric lighting into Leeds, and the result seems to be rather of the nature of "the cold shoulder." The contemporary making the above statement, goes on to say that the Municipality has, during the last three years, expended over £1,000 in considering the advisability of adopting the electric light, and has not arrived at a decision yet. More information is to be obtained, and more money expended. There is no reason for this delay, except the authorities at Leeds are in the condition of not knowing their own minds. Either they want the electric light or they do not. If they want it, the proper course to pursue is to employ a capable adviser, just as they would employ an adviser if a sewage scheme was under discussion or a new town hall to be built. Such names as Hopkinson, Kapp, Forbes, are not unknown as electrical engineers, and an appeal to an engineer who has made lighting a speciality would cost less than continual half-and-half measures. If the authorities do not want to take the lighting into their own hands, let one or other or all of the applicants for provisional orders have a free hand.

The questions before the authorities as to provisional orders are summed up thus: Must there be only one company? If so, which is best? What is to be the price of the light? What are to be the opportunities and terms of purchase afforded to the Corporation? As these questions concern all authorities when electric lighting is proposed, they may be briefly considered. Our answer to the first would be emphatic. One company and one only, unless the district was, like London, too large. Already in London mutterings of discontent are heard when one side of a street is in the hands of one company, and the other side in those of a second company. Again, when the time of purchase comes, negotiations with one company are preferable to negotiations with several. Authorities must decide as to the best company. The price will be stated by the applicant for the provisional order, and should be a maximum, not necessarily to be charged, and not permitted to be charged if the dividends to shareholders ranged above a certain agreed upon percentage. As regards purchase, there is only one just method, and that is to purchase the undertaking as a going concern at the valuation agreed upon by experts or by arbitration. Compulsory purchase at a fixed predetermined price is unjust, and will prove unworkable.

DUBLIN.

It is necessary to recur to this subject to say that the latest advices from Dublin are to the effect that the tenders of two companies, or rather tenders for a part of the work from each of two companies, have been accepted. We are, as yet, unable to give the exact portions of the work appropriated to each, but the favoured companies are:

1. The Electrical Company of Ireland.
2. The Irish House-to-House Electrical Company.

A reference to our issue of January 23 will show page 97, that the report of Messrs. Harty and Manville stated that "a good arrangement with two contractors might be made by selecting the Electrical Engineering Company of Ireland for the engines, boilers, and the public lighting plant, amounting to £16,033, and the Irish House-to-House Company for the alternators, regulating apparatus, transformers, meters, and cables, amounting to £15,244." It seems probable, then, that this suggestion has, in the end, been accepted, in preference to the giving of the whole work to the first named of these companies.

LIES.

Someone once said that a lie given 24 hours' start could never be overtaken. That seems to be true in connection with electrical matters, and especially with regard to electricity and fires. Only let an electric light wire be within a few miles (*à la* Artemus Ward) of the scene of accident, and forthwith the ubiquitous reporter to the local paper describes the conflagration as being caused by the electric light wires. No doubt careless workmanship has something, has much, indeed, to answer for in this direction, but the systematic jumping to this conclusion is "giving the dog a bad name," and is unmistakably stopping business. Novelists and writers in society papers are permitted to draw upon their imaginations—their productions would not be read were they not to do so—but the ordinary dry-as-dust penny a liner is supposed to be exact in his description, especially when he is "on the spot." Unfortunately the reporter is always on the spot, and as often has a go at electricity. It has struck some electrical engineers that "reporters" are almost to a man shareholders in "gas companies," and thus have unconsciously imbibed a bias against the rival illuminant. The most recent exemplification of diametrically opposed opinions is that at Cardiff. Men who sat at the table and saw the beginning of the fire, say it wasn't the electric apparatus; men who didn't sit at the table, but who were, of course, present, say it was; and those who were neither at the table nor present are in their conclusions divided. It did—it didn't. *Quien sabe.*

FERRANTI CENTRAL STATIONS.

A descriptive catalogue of the manufactures of Messrs. S. Z. de Ferranti and Co. has not hitherto been published. Their attention has, it seems, in great part been devoted to the supply of complete equipments for electric supply stations at home and abroad, which they have dealt with in each case specifically.

The enquiries, however, have become so numerous that the publication of a complete and ready catalogue of the plant and accessories required for electrical distribution on the Ferranti system has become necessary.

From the preface of this catalogue, which is to be issued shortly, we are able to quote the following information of some of the supply stations equipped with Ferranti plant, which will prove interesting to electrical engineers:

Grosvenor Gallery station, London.—This station was equipped with two alternators, and had as many as 35,000 lamps wired to the mains; the demand was such that the machines were frequently running for several hours at 50 per cent. more than their stated maximum output.
Deptford station is connected by four Ferranti concentric mains to various distributing stations which are now being completed in London. The capacity of the plant now erected at Deptford is 90,000 lamps, and this capacity is being increased by the building of two 200,000-light machines.
Rochester has a small station with a capacity of 3,000 lamps, which will shortly be extended.
Glasgow station has two alternators with a capacity of 6,000 lamps.
La Plata station, Argentine, has three alternators with a capacity of 9,000 lamps.
Rosario station, Argentine, has two alternators with a capacity of 6,000 lamps.
Barcelona station, Spain, has two alternators with a capacity of 6,000 lamps.
Municipal station, Paris, has three alternators with a capacity of 9,000 lamps.
Plaza de Toros, Paris, has one alternator with a capacity of 3,000 lamps.
Nancy has three alternators with a capacity of 9,000 lamps.
Havre has two alternators with a capacity of 12,000 lamps.
Melun has two alternators with a capacity of 6,000 lamps.
Troyes has two alternators with a capacity of 6,000 lamps.
Nimes has two alternators with a capacity of 6,000 lamps.
Dijon has one alternator with a capacity of 3,000 lamps.
Sens has one alternator with a capacity of 3,000 lamps.
St. Ceré has one alternator with a capacity of 600 lamps.

It may be pointed out that while a few of the smaller stations have been able to run continuously with single machines—*i.e.*, without reserve plant—their extension is either in hand or in contemplation.

Every facility is now afforded to contractors, supply companies, local authorities, and engineers requiring information upon the Ferranti system, and the company prefer, when possible, that their works at Charterhouse-square should be visited for that purpose.

SALFORD CORPORATION SEWAGE WORKS.

The Salford Corporation during the last year instituted an exhaustive series of experiments on the treatment of sewage, with the object of deciding on the most suitable system to adopt in the purification of the Salford sewage. In addition to the borough engineer (Mr. Arthur Jacob) the Corporation secured the services of Mr. Carter Bell, the borough analyst; Mr. John Newton, civil engineer; Dr. Burghardt and Mr. O. Giles, of Messrs. Mather and Platt's engineering works, to report on the various engineering, chemical, and electrical features of the systems experimented upon. The reports of these gentlemen have now been presented, and contain some interesting information. The magnitude of the question of the proper treatment of sewage and the difficulties involved in its accomplishment can scarcely be over-estimated. At the Local Government enquiry held with respect to the Manchester sewage scheme it was pointed out that the amount of sludge produced by the chemical treatment of sewage would be something like 200 tons per day. Although the Patent Office shows a record of many hundreds of attempts to deal with the sewage problem, it is one which is still far from being satisfactorily settled. So late as 1884 the Royal Commission which was appointed to enquire into the matter, after patiently investigating it for two years, had to report that "the efficient and effectual purification of sewage, according to our present state of knowledge, could not be effected by chemical means alone, but required a further filtration through land."

The systems which were submitted to trial at the Salford sewage works were the International, the Electrical, and the Aluminoferric, and the Barry systems. The borough engineer points out that in his opinion the main features which should influence the Corporation in their choice are—first, that the effluent or treated sewage which has to pass into the Ship Canal should be so purified that no nuisance will arise from it after decomposition, that the sludge produced should not exceed half the weight of the sludge produced by the lime process, that the efficacy of the process should be permanent, and that the working expenses and capital cost of the process should not be disproportionate to the result to be obtained. The sewage to be dealt with contains a large amount of manufacturing refuse from chemical and paper works, and Mr. Carter Bell has estimated that the bleaching powder and caustic drugs produced in the various paper works using the Irwell and the Roach must be something like 150 to 200 tons per week. About one-eighth part of the sewage treated at the works comes from the Pendleton sewers, and is richer in organic matter. Up to the present time the system of precipitation by lime, which has been found to give good results at Birmingham, Leeds, Bradford, and other large towns, has been the one adopted by the Salford Corporation; but the effluent resulting from the lime treatment is known to be subject to a process of secondary decomposition, which would unfit it for discharging into the confined waters of the Ship Canal, and the recent experiments were therefore entered upon with a view to discover some more efficacious method.

The International Water and Sewage Purification Company, Limited, undertook a series of experiments with their system, which is a filtering system, in use at Acton, Hendon, Tottenham, Swinton and Pendlebury, Royton, and other places, and has been very favourably reported on. Professor Frankland, who is perhaps the highest authority on such matters, stated in a report submitted to Major Tulloch, of the Local Government Board, that "no chemical process of purifying sewage had ever in his experience approached this in efficiency."

The system of the Electrical Purification Association, Limited, consists in passing an electrical current through the liquid sewage. No addition of chemicals is requisite, the necessary reagents being evolved from the sewage itself by electrolysis. It will be seen that the theoretical basis of the system is extremely simple, but its application necessarily involves a considerable outlay in channels for the sewage, electrodes, and dynamos. In the experiments at the Salford sewage works, which were designed to deal with 3,000 gallons of sewage per hour, the crude sewage was passed through a channel of brickwork 90ft. long and sufficiently large to contain the 364 plates of cast-iron which formed the electrodes. Each of these plates weighed about 2cwt. The sewage in its course along the narrow channel was subjected to the electric current passing between the electrodes, and the impurities were separated in the form of a flocculent scum, which floated on the surface. A period of quiescence was allowed in a tank set apart for the purpose, and the impurities then settled to the bottom, leaving the purified effluent to be withdrawn. The electric current was derived from a dynamo which, in the report of Mr. Giles, of Messrs. Mather and Platt, is described as of the Charlesworth and Hall type, with an output of 50 volts, 50 amperes, and was driven by a small inverted compound engine working at about 600 revolutions per minute, with 100lb. steam pressure. The current and E.M.F. were measured with instruments carefully tested with Messrs. Mather and Platt's instruments, and readings were registered hourly. In order to test the consumption of iron due to the decomposition of the iron plates, each plate was carefully weighed before being inserted in its place, and again washed, dried, and weighed at the completion of the experiments. The weight before commencing was 34 tons 8cwt. 2qr. 18¾lb., and at the conclusion they were found to have lost 1cwt. 1qr. 19⅝lb. As the daily flow of sewage is about 10 million gallons, the annual consumption of iron involved is shown to be something like 700 tons. The amount of sludge produced by the electrical system was smaller than by any of the other systems under consideration, and the quality of the effluent was excellent. In summing up his report on the chemical aspects of the two systems above named, Mr. Carter Bell says: "If the International or the Electrical Company will guarantee the Corporation of Salford to produce an effluent from the whole of the Salford sewage which shall equal the effluents they have produced during the last few months, then I think the Corporation will be justified in expending the large amount of money that would be involved in purifying the sewage."

The other system tested was the Aluminoferric system, using alum cake. The results were far from satisfactory from a chemical point of view; Mr. Carter Bell reporting that all the effluents were very unsightly from suspended matter, and also from being of a brown colour. As he could not distinguish by the appearance the effluents from the crude sewage, this was certainly not a system which he could recommend the Corporation to adopt.

ELECTRICAL STANDARDS COMMITTEE.

The following draft resolutions, with others, dealing with the practical measurement of power, whether developed by unvarying or alternating currents, will be submitted to the Electrical Standards Committee for discussion at their next meeting, which will take place on Friday, the 20th inst.

1. That it is desirable that new denominations of standards for the measurement of electricity should be made and approved by Her Majesty in Council as Board of Trade standards.

2. That the magnitudes of these standards should be determined with reference to the centimetre as unit of length, the gramme as unit of mass, and the second as unit of time, and that by the terms centimetre and gramme are meant the standards of those denominations deposited with the Board of Trade.

3. That the standard of electrical resistance should be denominated the ohm, and should have the value 1,000,000,000 in terms of the centimetre and second.

4. That the resistance offered to an unvarying electric current by a column of mercury of a constant cross-sectional area of one square millimetre, and of a length of 106·3 centimetres at the temperature of melting ice may be adopted as one ohm.

5. That the value of the standard of resistance constructed by a committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as ·9866 of the ohm.

6. That a material standard constructed in solid metal, and verified by comparison with the British Association unit, should be adopted as the Board of Trade standard ohm.

7. That for the purpose of replacing the standard, if lost, destroyed, or damaged, and for ordinary use, one or more copies should be constructed, which should be periodically compared with the standard ohm and with the British Association unit.

8. That the standard of electrical current should be denominated the ampere, and should have the value one-tenth (0·1) in terms of the centimetre, gramme, and second.

9. That an unvarying current which, when passed through a solution of nitrate of silver and water containing from 15 to 20 parts by weight of nitrate of silver in 100 parts of water, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of one ampere.

10. An alternating current of one ampere shall mean a current such that the square root of the time average of the square of its strength at each instant, in amperes, is unity.

11. That an instrument constructed on the principle of the balance in which, by the proper disposition of the conductors, forces of attraction and repulsion are produced which depend upon the amount of current passing, and are balanced by a known weight, should be adopted as the Board of Trade standard for the measurement of one ampere, whether the current be unvarying or alternating.

12. That the standard of electrical pressure should be denominated the volt, being the pressure which if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

13. That the electrical pressure at a temperature of 62deg. F. between the poles or electrodes of the voltaic cell known as Clark's cell, constructed and used in accordance with the specification attached to these *Proceedings*, may be taken as not differing by more than — parts in 1,000 from a pressure of — volts.

CONTINUOUS-CURRENT TRANSMISSION AT CALAIS.

The railway company at Calais in lighting their stations had to solve the problem of lighting three stations at some distance from each other in such a manner as to be independent of each other, while at a minimum cost for plant and maintenance. Calais being the point of embarkation for Dover, the whole station has been organised in a manner different to other stations to expedite as much as possible the progress of passengers. The station comprises, in reality, three stations at the points of a triangle about the same distance from each other—nearly two miles. Calais town is the one in use for ordinary passengers to this town from inland; Calais pier is reserved for the direct traffic between France and England; and the third is the Calais goods station. It is evident that the town station has no need of the light after a certain hour at night. On the other hand, the pier station needs light at certain irregular intervals at the arrival and departure of boats, while the goods station, in which the work of shunting is carried on all night, requires a constant illumination.

The problem has been solved, according to an interesting article in the *Bulletin Internationale de l'Electricité*, by constructing a central station with transmission of power for the respective service of each of the stations. At first it was proposed to use alternate currents, but this was abandoned from a fear of accidents to the staff, and the scheme was definitely adopted of using high-tension direct currents for motors which transform into low-tension direct currents by the mains of second dynamos.

The lighting comprises 30 arcs and 320 incandescents at Calais town, 23 arcs and 221 incandescents at Calais pier, and 20 arcs and 150 incandescents at Calais goods station.

The central generating plant installed at Calais town station comprises two steam engines of 250 h.p. each, at 90 revolutions per minute, driving four dynamos (horizontal field magnet type), giving at 700 revolutions a current of 27 amperes at a pressure of 1,000 volts.

Each of the other stations is connected with a double set of overhead lines to guard against accident. The length of each line is about two miles, a total in all of about 24 miles for the double lines for the three stations. The section of the copper is 38 mm. square.

The pier and the goods stations, respectively, have two motors each of exactly the same type as the dynamos on the generating station. Each of these is coupled direct to two Manchester dynamos, giving 200 amperes at 70 volts, making four dynamos for lighting at each station.

The arc lamps are of three different systems—Cance, Pilsen, and Maquaire—and are run in parallel with 70 volts at the terminals of the machines, and 55 volts at the lamps. Besides this a battery of 160 accumulators, of a total capacity of 700 ampere-hours, are placed at Calais pier station. The two other stations are furnished with similar batteries.

It is thus seen that the independence of the three stations is complete. Any one of them needing light has only to start its motors, and when the dynamos have built up to full pressure, switch on the lamps.

This installation, which has been working since May, 1890, has experienced no accident whatever since starting.

NOTES ON THE ELECTRIC RAILWAY: HISTORICAL, STATISTICAL, AND TECHNICAL.*

BY FRANKLIN LEONARD POPE.

Every trade and profession has its well-worn stock of traditional anecdotes, handed down from a remote antiquity, which the veterans are accustomed to relate in hours of idleness for the amazement, or the amusement, as the case may be, of the youngsters.

The telegraphic service, in which 30 years ago I was an aspiring and ambitious youthful "plug," was no exception to the rule. You will pardon me if I recapitulate two of these ancient tales, which I tell as they were told to me, for the sake of the moral which they point.

One of these stories was to the effect that an inventive genius down East, which meant Boston or beyond, had once contrived a great improvement on the telegraph as we knew it, inasmuch as by its means the telegraph operators, or anyone else for that matter, could converse directly through the wire.

"A most magnificent invention," solemnly asseverated our chief operator, Jack Selden; "it was tried with perfect success between Boston and New York, but, sad to say, it had to be given up, because the New York operator's breath smelt so strongly of bad whisky." But in later days Alexander Graham Bell, of Boston, did actually show us how to speak through the whispering wire, and owing, let us charitably hope, to the permanent reformation of the objectionable habits of the New York operators, it did not this time "have to be given up."

The other story was about an unsophisticated old man, a shoemaker, who lived and had a little shop in Natick, between Worcester and Boston; for aught I know, he may have been the original "Natick cobbler." The only son of this old man was a soldier in our army in Mexico This was in 1848, when the telegraph was a new thing and a great mystery, and its frequent despatches, bringing the latest news from the seat of war, kept the community in a continual state of feverish anxiety, of which in later years we all came too well to know the full meaning. One day a letter came to the shoemaker from his son complaining of the condition of his boots, worn to shreds by long and hard marches, and wishing that he had a durable pair of the paternal manufacture. Struck with a happy thought, the good old man immediately constructed a pair of his very best No. 12 cowhides, affixing a tag to them inscribed with the proper address, tied the straps together, and hung the boots over the telegraph wire which passed his house. In the morning they were gone. A belated tramp had appropriated them, and with a certain sense of grim humour not unknown among these gentry, had hung his own dilapidated brogans in their place. "Look, Marthy," exclaimed the delighted cordwainer the next morning as he gazed out of his window in the dim light of dawn, "Johnny has got his new boots so quick, and has sent his old ones back by telegraph to be mended."

But to-day the improbable romance of the talking wire, and the imagined electrical transportation of the simple cobbler of Natick, have both become realities. The speaking telephone is found in every business office and in almost every home. Freight and passengers are hauled over elevated ways by electric power, and probably no one in this audience entertains a doubt that the day is close at hand when the electric transportation of passengers will be conducted at a rate of speed which most people now deem almost inconceivable.

Every consideration of common humanity, not to speak of public convenience and economy, unite to urge the speediest possible substitution of mechanical for horse power on our numerous street railways, and this is for many reasons especially to be desired in cities in which the most desirable residential neighbourhoods can be reached only by routes including long and comparatively steep ascending grades. It is but just to the street railway managers of the United States to say that these considerations have not been without effect.

It is only six years ago that an electric street railway was put in actual commercial service in the United States for the first time. This was in the city of Cleveland, O. To-day considerable more than one-third of the total street railway mileage of the United States is either operated by electric power or contracts have been entered into for the substitution of an electric equipment for that now in use, at the earliest possible moment.

At a meeting of the American Street Railway Association held in Washington only a little more than two years ago, almost the sole subject of discussion was the question of improved motive power for street railway service. Every manager and superintendent present realised that the demands of traffic were rapidly outgrowing the existing methods, and many of them had begun to look forward to the application of electric power as the only possible solution of the problem. As one delegate after another reported his experiences and observations in respect to electric traction, a member who had listened to it all with evident impatience arose and entered his solemn protest against all the new-fangled talk about electricity. He said that he had come there upon the assumption that it was a horse-railroad convention in order to get information about horses. He wanted to know how to shoe them, how to feed them, and how to work them to the best advantage; and as he continued to complain, it was evident that in more than one place in the assemblage his ideas met with a sympathetic response.

Less than four months ago the same association held its annual meeting at Buffalo, and in his opening address the president, Thomas Lowry, of Minneapolis, made the following significant remark:

"I am so thoroughly convinced that electricity is the coming power for street railways (except on very heavy grades, where the cable is best suited), and that it will prove so effective as a means of rapid transit for cities, that I believe that this is the last convention that will ever seriously consider horses for the operation of street railways."

Nor was this all. Many of you who are familiar with the fact that President Lowry, whose energy, ability, and foresight will never be questioned by anyone familiar with his career, threw away, in 1889, a brand new cable plant, which cost nearly half a million dollars, in order to replace it with electric motors.

Some of his associates undoubtedly entertained grave doubts of his sanity, but every new electric road brings a fresh tribute of approval to his enterprise and to his courage. Since he took that memorable action, electricity has changed the whole aspect, both scientific and commercial, of municipal transportation.

Few people have any conception of the enormous extent of city and suburban traffic in the cities of the United States. A few statistics are more impressive than pages of rhetoric.

The official returns show that during the year ending

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* Paper read before the New York Electric Club, Jan. 22.

Sept. 30, 1889, the 110 street railways in the State of New York carried over 686,000,000 passengers, or 100 times the total population. In New York City alone the surface and the elevated roads carried together about 400,000,000. In Boston 100,000,000, and in Philadelphia 150,000,000 passengers were carried. In fact, statistics indicate that the street railways of the United States carry something like twice as many passengers as all the steam roads, and, moreover, it has also been found that the number of passengers increases from year to year in a much greater ratio than the population, which means, not only that more people ride, but that the same people ride more frequently each succeeding year.

The transportation of this enormous number of passengers—probably not less than four or five billions, taking the whole country together—with safety, comfort, speed, and economy, must be recognised as an undertaking of the most gigantic description. It is well worth our efforts to carefully consider the best means by which it can be accomplished. No work has ever been done by the inventor, the engineer or the electrician, of such immediate and direct benefit to the masses, as that which has to do with the subject under consideration.

Considered in a general sense, the electric car is a self-propelling vehicle, the actuating force of which is derived from an electric current, through the agency of an electric engine, or, as it is technically termed, a motor. We may conveniently consider the subject of electric railways by dividing them into three classes, which are distinguished from each other in the manner in which the current is supplied to the motor upon the car. These are :

1. The so-called overhead system, in which the electric current is supplied to the car through a wire suspended above the track.

2. The underground system, in which a supply conductor is placed in a conduit beneath the surface of the street, and the current is taken into the car by an arm projecting downward through a slot in the top of the conduit.

3. The storage battery system, in which the current is furnished by storage batteries (which are, in fact, a species of electrical reservoirs) placed underneath the seats of the car, and charged at the terminal station with a sufficient quantity of electricity for each trip.

While differing from each other in respect to the manner in which the current is supplied, certain essential principles are common to them all. In all electric cars the motor is composed of a stationary portion called the field magnet, and a moving portion called the armature. The electric current causes the armature to revolve, and the armatures being geared to the car axles move the car. The driver starts the car by establishing an electric connection between the motor and the electric conductor, overhead or underground, or the storage battery, as the case may be, stops the car by interrupting the electric connection, and reverses it by reversing the direction of the current which passes through the motor.

The time which I have allowed myself will not permit me to enter as fully as I should like into the history of the electric motor, but there are certain prominent epochs in its development which require a passing notice.

The discovery that it is possible to produce continuous mechanical motion by the agency of the electric current is due to an eminent English philosopher. It was made early on the morning of Dec. 25, 1821. For many years this discovery was regarded as nothing more than an interesting philosophical experiment, but the world is now awakening to some adequate conception of the magnificent possibilities of the humble gift which was slipped into its stocking on that Christmas morning, by one who had not long before jocosely described himself as "Michael Faraday, late bookbinder's apprentice, now turned philosopher."

In 1831 Joseph Henry, then Professor of Natural Philosophy in the Academy at Albany, N.Y., and afterwards the distinguished secretary of the Smithsonian Institution at Washington, in a letter to Prof. Silliman, of New Haven, said : "I have lately succeeded in producing motion by a little machine which I believe has never before been applied in mechanics, by magnetic attraction and repulsion." This was a crude and simple affair, but served sufficiently to illustrate the principle of such apparatus. Those who are interested to see it will find it carefully preserved in the cabinet of Princeton College.

Having thus demonstrated the possibility of constructing an electromagnetic engine, so far from giving way to the natural enthusiasm of the successful inventor, Henry proceeded, with that calm sobriety of judgment for which he was peculiarly distinguished, to forecast the future possibilities of the new motor. He was soon led to see that under the conditions of knowledge then existing the power could only be derived from the oxidation of zinc in a galvanic battery, and hence the heat energy required in the original smelting of the metal must represent at least an equal amount of power. Hence his conclusion that the fuel required for that purpose might with better advantage be employed directly in performing the required work.

While feeling thus assured that electricity could not hope to compete with, much less to supersede, steam as a primary source of power, Henry, nevertheless, did not hesitate to predict that the electric motor was destined in the future to occupy an extensive field of usefulness, particularly in applications in which absolute theoretical economy was subordinate to more important considerations.

Time has shown that Henry's conception of the legitimate field of the electric motor was prophetically accurate, but his views failed to impress themselves upon the minds of his contemporaries. In the expectation that electricity would soon be the universal motive power, the problem of its utilisation was during the next 10 years attacked with great zeal by a considerable number of inventors. The earliest as well as the most meritorious of these was a Green Mountain village blacksmith by the name of Thomas Davenport. Some time since, while preparing a lecture to be delivered before the Board of Trade, in Springfield, Mass., I accidentally learned that this inventor had constructed a model of an electric railway in Springfield more than 50 years ago, undoubtedly the very first appearance of the electric railway in the history of the world. The work of this pioneer electrician, and even his very name, being almost unknown to the present generation of labourers in this fertile field, my curiosity and interest were sufficiently excited to lead me to undertake an investigation, with a view to rescue whatever knowledge of his work had escaped the ravages of time. In this it has been my fortune to meet with an unexpected degree of success. The record of his career shows that Thomas Davenport was a man of no ordinary merit, pursuing the occupation of a village blacksmith in Brandon, Vt., at that time an obscure country town, far removed from all main lines of travel and transportation, and long before the day of railroads, but as Prof. Eaton justly said of him, "possessing one of those minds which cannot be confined to the limits of a blacksmith's shop, nor any other shop less than the canopy of heaven," he had no sooner been shown as a curiosity the effect of Prof. Henry's electromagnet in lifting a blacksmith's anvil by the magnetic power generated by three small battery cells than he was seized with the idea that electromagnetism might be applied to the propulsion of all kinds of machinery, and, in fact, might be made a universal motive power. From that moment his whole life was devoted solely to the realisation of this conception.

(To be continued).

THE DEVELOPMENT OF THE ELECTROMOTOR.

The electromotor has ceased to be a curiosity and has taken its place as a piece of ordinary everyday machinery. It is being applied to such a variety of uses that it is difficult to prophesy to what extent its use may not grow in the near future. It furnishes us, without doubt, with one of the most economical means of transmitting energy, and this, combined with its portability and reliability, ensures its adoption in numberless directions.

Already the "boom" for "electric traction," or the propulsion of tram and railway cars by its means, has commenced, and one has only to listen to ordinary conversation to hear of new ways in which it is proposed to utilise it. In electric cranes, electrically wound clocks, electrically worked pumps, the transmission of energy over long distances, the distribution and economical subdivision of energy in factories, and in many other ways electric motors find everyday application.

This being the case, it will not be inopportune at the present time for us to pass in review the chief stages of its development from the rotating wheel of 1830 to its present form, to note how our ideas as to its mode of action have gradually formed, and to explain in a popular form the various modifications motors have to undergo in order to enable them to be economically employed under widely differing conditions.

The electromotor dates from 1830, for it was in that year that Michael Faraday, our illustrious fellow-countryman, discovered that we could generate electric currents by rotating a closed conductor, placed at right angles to a magnet, in a magnetic field.

Faraday did not follow this discovery up, but left others to tread in the path he had indicated. Sturgeon soon after brought out his simple rotating wheel, of which a description is given in many text-books on electro-dynamics, and Prof. Henry introduced, in America, his method of obtaining powerful electromagnets by winding many coils of wire round a soft-iron core. Barlow, Page, Davidson, and Ritchie are but a few of those pioneers who during the next few years invented and perfected various means of producing rotation by means of the reactions taking place between a wire carrying a current of electricity and a magnet. These are interesting from a historical point of view, but a detailed description of them does not enter within the scope of this paper.

Some of these early motors were of considerable size, for we read that in 1839 Prof. Jacobi, of St. Petersburg, who paid a great deal of attention to this subject, constructed one large enough to propel a boat holding 12 persons at a speed of 2½ miles an hour on the River Neva, using as the means of obtaining his current 64 large Grove cells. Motors were also constructed by other experimenters large enough to work at 10 h.p., but the cost of producing the current to drive them from primary batteries, and the lack of knowledge as to the principles underlying motor action, sufficiently explains why so many of these wonders were relegated to the lumber-room.

The fact which, for a time, was a sore stumbling block was this—the motor started all right, but as the speed increased the current passing through it decreased, therefore, it was urged, the resistance of the armature must increase. This was certainly puzzling, and although men thought it a deathblow to their hopes of an economical machine, when properly understood it proved to be one of its chief merits.

It was Jacobi who found the clue to this mystery, and even he did not fully appreciate the meaning of his explanation, while others for a long time did not accept it. He noticed that when the motor was working it acted as a generator on its own account, and produced an E.M.F. acting in opposition to that driving it, and consequently decreasing the current. He enunciated the following law to which, when speaking of the work obtainable from a motor, we shall have occasion to refer:

"The mechanical work given out by a motor is a maximum when the motor is geared to run at such a speed that the current is reduced to half the strength it would have if the motor were stopped."

This showed that a motor did most work when half the current was used in warming up the machine, and when accepted, as it ultimately was, it led to the general though not universal opinion that a motor could not attain a greater efficiency than 50 per cent.; electricians did not generally grasp the fact that although a motor might do most work when working under these conditions, yet it might not do it in the most economical manner.

Meanwhile, the modern dynamo machine had been gradually evolved; in 1856, the introduction of Siemens's shuttle-wound armature had greatly improved the magneto machine, and in 1863 the now historic Pacinotti machine was made by a professor of that name at Pisa, in Italy. For some years the description of this machine, published in an Italian magazine, was unnoticed, and in 1867 the self-exciting principle appears to have been rediscovered by Wheatstone, Varley, and Siemens, all working independently of each other. The two ways of winding field magnets "in series" and "in shunt" with the armature were found out, and when, in 1870, Gramme added to the general stock of knowledge his method of making and winding ring armatures and the Von Alteneck way of winding drum armatures was introduced, our modern dynamo was complete.

These machines were found to work as motors, and Siemens soon afterwards showed that Jacobi's law did not relate to "maximum efficiency," but only to "maximum activity," or rate of doing work, for he exhibited one of his dynamos working as a motor at an efficiency of 67 per cent.; an impossibility if Jacobi's law was to be received as popularly understood.

He stated that we obtained maximum efficiency when the relation of useful work done by the motor to the total amount of energy taken from the current bears the same ratio as the back or counter E.M.F. generated by the motor to the E.M.F. at the terminals of the motor. This is now usually called "Siemens's law of maximum efficiency," and when speaking of this in the subject we shall have occasion to recur to it.

Electromotor science was now well under way; it was seen that the production of a counter E.M.F. by the machine itself was no drawback, but only a fresh confirmation of the great principle of the conservation of energy. The motor as we now know it was an accomplished fact, and the next thing to find out was how best to design it, and how to modify the design to suit varying conditions of supply and varying requirements of work.

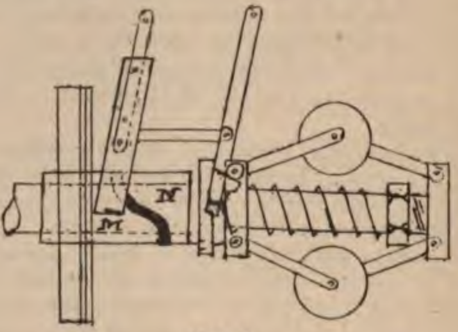

Fig. 1.

The first attempt at a complete scientific explanation of motor action was made by Profs. Ayrton and Perry, who, in March, 1883, read a paper on "Electromotors and their Government," before the Society of Telegraph Engineers. This proved to be a very valuable contribution to electromotor science, for after reviewing previously known facts, they went on to state their own views on the matter. Although through lack of time no discussion took place then, yet since, both in the Press and on the platform, their conclusions have been strongly opposed; and by noting the arguments used by both parties, we may learn a great deal. It will be well to find out what these varied views are.

Commencing by saying that the chief advantages of motors were four, Profs. Ayrton and Perry went on to enumerate them—viz.:

1. Portability.
2. Small weight per horse-power of work done.
3. Ability to be used at a distance from the prime mover.
4. That they work to better advantage when running fast.

Then, after reminding their hearers of the two ways of winding field magnet circuits—viz., "in series" or "in shunt" with the armature—they went on to describe various methods of governing the speed at which motors run under varying loads and varying conditions of supply.

Dealing first with supply at constant potential and varying load, they say: "A motor can be governed to run at the same speed, whatever work it may be doing, in one or other of two distinct ways. First, the power may be cut off in proportion as the work is cut off; or, second, a brake may be employed to replace the useful load removed."

The device then in use for governing by the first mentioned method was called the "spasmodic governor," and after reading the description of it, those will fully appreciate it who have had any experience with mercury spark.

It consisted of a cup containing mercury, into the centre of which a wire was led, thus completing the electrical circuit. This cup rotated with the armature, and at low speeds the circuit continued closed. When it ran fast, however, owing to the fact that the surface of the mercury assumed a circular form, being of course depressed in the centre, the wire ceased to dip into the mercury, the circuit was broken, the current interrupted, and the motor slowed down. The wire again dips into the mercury and the motor commences to run a little faster; by this means a rough kind of government is carried on.

They proposed, as an improvement upon this, the "periodic governor," of which a drawing is given above. Instead of shutting off all the power when too much was supplied, it only cut off a portion of it during a part of each revolution, the time during which the smaller supply was given being governed by the work. This was done in the following manner. On a continuation of the armature spindle two circular pieces of metal, M N, shaped as in the diagram, insulated from the spindle, and connected with each other through a resistance, were placed. Upon this a brush rests, and the position of this brush is regulated by the speed by means of the governor balls. As the motor runs faster the governor balls diverge, and the brush is brought for a longer period upon the part where less current is supplied, and the motor, consequently, is slowed down, only again to be accelerated when, by the governor balls collapsing, the brush is moved upon the other portion of the collector for a longer time, and more current is given to the motor. Governors of this class all suffer from the defect of excessive sparking, a fault which practical men will say altogether disqualifies them from general adoption. Partly for this reason, and partly, also, because at the best only jerky and imperfect regulation is possible by these ways, the writers recommended government by electrical means on their second method, and suggested the following arrangements:

1. The armature of a small series-wound motor was connected with the armature spindle of the motor. The external circuit of the small dynamo is so arranged that its critical speed is the same as the required constant speed of the motor. When the motor runs below its proper speed but little current is generated by the small dynamo, and consequently not much energy being absorbed from the motor, it acts as a weak brake. When the speed, however, gets above the required limit, much more current is generated by the dynamo, much more energy taken from the motor, and immediately it acts as a powerful brake and tries to pull the motor speed down.

2. They proposed using a small magneto machine in conjunction with the motor, the current generated by the small dynamo being led round the motor magnets in such a direction as to weaken them. The armature of the magneto machine is mounted on the same spindle as the motor armature. The resistance of the circuit is constant, therefore the current will increase in the same ratio as the E.M.F., which is in its turn dependent upon the speed. Therefore when the motor "races," the action of the magneto machine is to cause it to slow down; if it slows down, the field magnets become stronger and the speed is increased. Regulation by these means was not perfect, and these combinations of two machines soon grew obsolete.

Profs. Ayrton and Perry, in explaining these methods of government, compared the action of the small dynamo to that of a brake which acted in opposition to the motor, and balanced any inequalities of external work.

Various modifications of these ways were proposed to render them suitable for constant current circuits, but as these ways are not at the present time in use, it does not fall inside the scope of this paper to describe them.

Passing on from the subject of the government of motors, they went on to investigate into the proper relative proportions of armature and field magnet. From mathematical and theoretical considerations, they came to the conclusion that in a motor to obtain maximum output from a machine of a given weight, the armature should form 90 per cent. of the total weight and the field magnets 10 per cent., while for a dynamo the reverse held good—viz., 10 per cent. for armature and 90 per cent. for field magnets. We conclude from this that in their opinion at that time a good motor was a very different thing from a good dynamo, and we may prove this by the following two quotations from this part of their paper.

"We cannot lay too much stress on the importance of this fact, that a motor must work mainly by attractive force and not by repulsive force. The magnetic fields due to the field magnet and armature must help one another and not oppose one another, as is the case with a dynamo."

Further on they say:

"We have every reason to believe, therefore, that an investigation concerning these relative sizes in a motor made to any design, such as we can at present imagine, if soft iron is used in the field magnet, must have the result that the armature part ought to form a much greater part of the whole weight than the field magnet part, whereas in a dynamo machine it is the armature to which the very small weight must be given."

These quotations show clearly what was intended by the writers.

They exhibited at the same time their own motor, which they were then introducing, and which in appearance was very unlike our present types. The armature, which was the outside portion and fixed, was of the Pacinotti form, the field magnets to which the brushes were fastened looking like a Siemens shuttle-wound armature. The commutator was fixed, and the brush in rotating pressed successively against every part of it. The efficiency of a small one which weighed 37lb., and whose output was about one-fifth of a horse-power, was about 40 per cent. when running at 1,576 revolutions per minute.

Mr. Mordey has been very prominent in his opposition to Profs. Ayrton and Perry's views on this subject. Looking at a dynamo as a reversible machine, he approached the subject from a different standpoint. While the writers of the paper appeared to consider maximum output for minimum weight as the chief end to aim at in designing motors, Mr. Mordey and others argued that other considerations, such as minimum sparking and small amount of attention required in using them, were quite, if not more important. Instead of thinking of motors as working because of the magnetic attraction between the poles of the field magnets and the magnet poles in the armature core which are produced at the points in the armature where the current enters and leaves it, by the circulation of the armature current round the armature conductors, as Profs. Ayrton and Perry appeared to do, they preferred to consider the iron of the armature core as acting the part merely of a conductor for the magnetic energy of the field magnets, and the rotation of the armature to be due to the reactions caused by the presence of the armature conductor with a current flowing along it, in the magnetic field produced by the field magnets.

This way of looking at motor actions greatly simplifies them, and soon leads us to enquire whether further analogies may not be found between dynamos and motors, and if, after all, a good dynamo may not prove itself to be an equally good motor. Of course it would be unfair to compare a dynamo where only high efficiency had been considered in the design, with a motor where light weight had been made the chief aim. But when designed for similar conditions of work, ought not the best dynamo to prove the best motor? Mr. Mordey and his followers said "Yes," and the general agreement of practice to-day with their views proves to many minds their case. In dynamos the prevailing idea has been to keep the magnetic field as powerful as possible in comparison with the armature, and so to reduce as much as possible the variations of lead and the difficulties of sparking. We find that if we work on similar lines with motors we obtain similarly satisfactory results.

In the *Philosophical Magazine* for January, 1886, Mr. Mordey published the following results of some experiments he had made with a Victoria dynamo, at the works of the Anglo-American Brush Corporation. If we have a shunt-wound dynamo, with a very low armature resistance, and drive it at a constant speed, we find that the terminal difference of potential remains nearly constant during a long range of output. Mr. Mordey, to prove the converse of this, took a low resistance armature shunt-wound Victoria dynamo and supplied it with current at constant potential, and obtained the following results :

Speed.	Current.	Diff. pot. at terminals of motor.	Horse-power taken from motor.
975 rev.	36·3 amp.	140 v.	1·8
965 ,,	66·5 ,,	,,	6·6
948 ,,	97·1 ,,	,,	12·87
945 ,,	130·8 ,,	,,	16·3

The difference in speed with loads varying from 1·8 to 16·3 h.p. is 3 per cent.

Speed.	Current.	Diff. pot. at terminals of motor.	Horse-power taken from motor.
680 rev.	29 amp.	100 v.	1
677 ,,	61·4 ,,	,,	4·8
675 ,,	102 ,,	,,	9·14
660 ,,	123 ,,	,,	11·7

Here, again, the maximum variation of speed does not exceed 3 per cent.

This proved conclusively that for all practical purposes, when constant-potential circuits are used, a shunt-wound motor having a very low armature resistance, and consequently one in which the armature would be small compared with the field magnets, was the most suitable arrangement wherewith to obtain approximately constant speed for varying loads.

Meanwhile the practice of motor manufacturers was tending towards the same ends. Profs. Ayrton and Perry's design had become obsolete, and types gradually approaching nearer and nearer to our present dynamo forms were forthcoming.

The Griscom, a small American motor, was introduced into this country with the object of popularising the use of motors worked from primary batteries for domestic purposes, but it did not appear to meet with striking success. In this the armature was of the Siemens shuttle-wound type, and the field magnets of the shape known as the double-horseshoe form.

The De Meritens, Reckenzaun, and Immisch motors also made their appearance. Of these the Immisch was one which had certainly come to stay. In this machine the armature is a little larger in proportion to the field magnets than is usually the case with a dynamo, but the magnetic effects of the field magnets so overpowers that of the armature that usually the makers send them out with their brushholders fixed, considering no adjustment to be necessary. As now made, these motors still more nearly resemble dynamos, and because of their good mechanical construction, and the careful attention shown to electrical details, they have won for themselves a commendable reputation.

Messrs. Elwell-Parker, Mr. Reckenzaun, and others who were at work utilising the motor for tramcar propulsion, used as little iron as possible in their field magnets, but of as good quality as obtainable; in fact, in many of our present tramcar motors the magnetic effects due to the field magnet so overpower those due to the armature, that the brushes are fixed once at right angles to the magnet poles, and are not moved even when the direction of rotation of the armature is altered.

In the United States about this time the introduction of electrically-propelled tramcars went on apace, and among the many pioneers in this field Mr. Sprague occupies a prominent position. In October, 1886, he published in the American technical journals a description of his now well-known system of electric traction. In his motor, by using the very best iron in his field magnets, he was able to keep them powerful relatively to the armature. Apparently ignorant of Profs. Ayrton and Perry's differential mode of field magnet winding, and of Prof. S. P. Thompson's work as embodied in his "Dynamo Electric Machinery," published in 1884, he claimed to have discovered the facts :

1. That a shunt-wound motor runs faster if its magnetic field is weakened by inserting resistance into its field magnet circuit.

2. That by differentially winding the field magnets of a motor you may obtain perfect speed regulation for varying loads. Although he fully appreciated this result of differential winding, he appears to have considered as its chief advantage for tramcar work, the fact that he was able by weakening his magnetic field so to distort it that the magnetic effect of the increased armature current was neutralised, and adjustment of brushes for varying loads avoided.

That a shunt-wound motor runs faster when its field magnets are weakened, though at first sight paradoxical, is really what we might expect. Upon what does the "torque," or turning moment, of a motor depend? We find that it depends upon two things, the strength of the magnetic field and the amount of current passing along the armature conductor, and that it may be expressed as the product of these two terms suitably expressed. Although weakening the field magnet may lessen one of these factors—the strength of the magnetic field—yet at the same time it increases the other to a greater degree, for the magnetic field being weaker, a lower counter E.M.F. is generated, more current passes through the armature, and the product of the two, which is the expression for the "torque," is greater, consequently the motor runs faster.

With reference to the second claim, it was pointed out a month or two later by Prof. S. P. Thompson that this was in reality only an application of Ayrton and Perry's theory, and that he had so regarded it, and therefore that what was called Sprague's law of winding—viz., "that the number of turns in the shunt coil of the field magnet circuit must bear the same ratio to the number in the series coil as the resistance of the shunt coil and the armature"—was known previously. This drew from Mr. Sprague the challenge that both he and Prof. Thompson should make a motor on principles known prior to 1881, and that these should be tested by some impartial electrician. The challenge, however, was not accepted, and in April, 1888, Mr. Sprague published a lengthy reply, in which he further tried to substantiate his claim.

A feature of novelty in his method of motor regulation, and one that greatly increased its utility, was his proposal when starting the motor to reverse the direction of the current in the series coil, so that instead of acting differentially—*i.e.*, weakening the field magnet—it strengthened it, and so increased its starting power. When the motor was started, he altered the direction of the current in this coil so that it acted differentially. Previous to this time the fact that in all differentially-wound motors the large current used at starting was sufficient oftentimes to completely reverse the polarity of the field magnet, and so cause the motor to start backwards, had proved very troublesome.

Meanwhile—that is, during the summer and autumn of 1886—an interesting discussion, in which Mr. Mordey, Mr. Esson, Profs. Ayrton and Perry, and some others, had taken part, had been carried on in the technical journals, in which the vexed question how best to design a motor had been fully discussed. Mr. Mordey and Mr. Esson, among others, were strongly in favour of powerful magnets, relatively weak armatures, and small amount of lead ; while Profs. Ayrton and Perry still maintained their old position, and endeavoured, though in a slightly modified form, to enforce their views. Again last spring, during the discussion at the Institution of Electrical Engineers on the two papers—Mr. Swinburne's on "The Theory of Armature Reactions in Dynamos," and Mr. Esson's "Some Points in Dynamo and Motor Design"—the question came to the front. Mr. Swinburne said : "A motor is nothing but a dynamo running the other way, as a dynamo is a practically reversible machine"; while Mr. Esson was quite as sure that the armature should not be the preponderating portion. Prof. Ayrton gave the results of some experiments he had had made, details of which will be found in the *Journal* of the Institution (Vol. XIX., Part 85, p. 180), and among other things, mentioned that Mr. Snell had told him that Messrs. Immisch put 10 per cent. more iron into the field magnets of their machines when manufactured as dynamos, than when as motors of the same size. Mr. Mordey and Mr. Swinburne replied, and the long controversy has ended by the general adoption of Mr. Mordey's views.

At the meeting of the British Association in Birmingham in 1886, Mr. Mordey read a short paper "On an Electric Motor Phenomenon," which, as it brings to notice a peculiarity of these machines, may fitly be mentioned here. He was testing a 30-h.p. series-wound Brush motor, constructed to work with a current of 20 amperes. He found, on connecting it up and starting the generator, that it only ran slowly, and would not do much work. Wishing to find out what was wrong he pulled out one of the connections from the terminals, when the motor stopped suddenly and then commenced to run backwards rather faster than it did before, gradually, however, slowing down until it came to rest. On examination he found that the series winding of the field magnets had by mistake been connected "in shunt" with the armature. Hence, the resistance of the field magnet circuit being very small, most of the current had gone round them, very little through the armature, and the "torque," or turning moment, had been small.

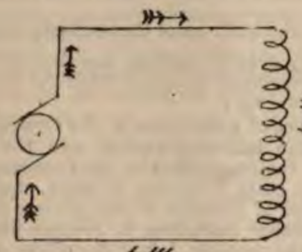

FIG. 2.

While the motor was rotating it was, of course, developing a counter E.M.F., small in this case because it was running slow, but when the circuit was broken this was able to send an appreciable current, in the reverse direction through the armature, but the same way round the field magnets, Figs. 2 and 3, because the resistance of the field magnet circuit was so small. Under these conditions the motor tried to start in the opposite direction, but was opposed at first by the inertia of the moving armature, which it quickly neutralised, and the motor stopped. This sudden stoppage of the current induces a momentary current in the same direction, which, under the peculiar conditions here present, is sufficient to so strengthen the field magnets that the armature is started again in the reverse direction to that in which it was originally running. These conditions are present in all shunt-wound motors, but the high resistance of the shunt circuit prevents, as a rule, the results above mentioned occurring.

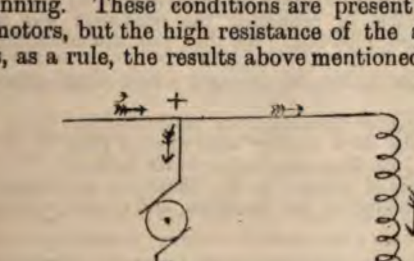

FIG. 3.

Having thus reviewed some of the chief facts connected with motors, dealing with them from an historical point of view, it would now be well to summarise our results and add anything else which might help us towards getting a clear perception of motor action.

There are two ways of winding the field magnets of motors, putting them either "in series" or "in shunt" with the armature.

Series-wound motors are extremely useful in cases where great starting power is required. Owing to the fact that when starting the magnets are fully excited and the armature current is also a maximum, the torque is greater than under any other conditions. They are, however, very sensitive to changes in load, and this renders them unsuitable for use when steady running is required.

If we wish to reverse the direction of rotation of a series-wound motor, we must remember that simply reversing the current through the machine will not do it, although we may alter in this way its polarity. We must only alter the direction of the current through either the armature or field magnet part.

Shunt-wound motors have very little torque or starting power. It is sometimes said they have none. An ideal one would not have any, as in such a motor the field magnets would be made of such perfectly soft iron that they retain no permanent magnetism. The resistance of the armature being *nil*, all the current would circulate round it, the magnets would be left unmagnetised, and no torque would be produced. In practice, however, these conditions do not hold good. We have both a small quantity of armature resistance and permanent magnetism, so that the motor will start, and the more readily the further it is from ideal perfection. If any practical difficulty arises from this source, do not switch the current through the armature until the field magnets have had time to magnetise.

The results quoted previously in this paper show how on constant-potential circuits motors are within a very small range self-regulating. This renders them extremely useful for practical purposes.

The efficiency of the motor depends upon a due appreciation of the laws of Jacobi and Siemens, both of which have been already stated and explained. Speaking generally, the faster we run our motor the more efficient it is; in fact, theory tells us that we get 100 per cent. when the counter E.M.F. generated by the motor is equal to the terminal E.M.F., but as in this case we should have no current, and consequently should be unable to do any work at all, we are obliged to be content with more practical figures. In recent machines, 94 and 95 per cent., when doing full work, have often been obtained. Those of us, therefore, who are looking forward to the time when motors will not only be generally used in factories and tramcars, but also for domestic purposes in every household, may well be satisfied with the machine we pride ourselves in having helped to bring to the state of perfection it at present occupies.

LEGAL INTELLIGENCE.

DICKINS v. THE METROPOLITAN ELECTRIC SUPPLY COMPANY, LIMITED.

This case came before the Master of the Rolls, and Lords Justices Bowen and Fry, in the Court of Appeal, on Wednesday. It was an application for a new trial. The action was brought (*vide E.E.*, Nov. 28, p. 486, vol. vi.) by Messrs. Dickins and Jones, drapers, of Regent-street, against the defendants, who were supplying them with current, for damages for suddenly cutting off the supply and plunging their premises into darkness. It appeared that in 1888 the plaintiffs were supplied with current by Mr. Pritchett under an agreement which, however, was not signed, but which purported to be terminable by six months' notice on either side. The defendants in March, 1889, took over the business of Pritchett, and wrote to the plaintiffs to inform them of their having done so, and the plaintiffs paid the quarterly payments due for the supply thenceforward to the defendants. In May the defendants wrote to the plaintiffs saying that they contemplated closing all the old agreements, and enclosing a form for a new agreement for the supply of electricity, which they requested the plaintiffs to fill up and return if they wished the supply to be continued. The plaintiffs put the agreement away, and inadvertently forgot to take any notice of the defendants' letter. The supply was continued as before, and the quarterly payments on the footing of the agreement with Pritchett were made by the plaintiffs to the defendants. On September 26, 1889, the defendants wrote saying that as they were turned out of the plaintiffs' parish they would not be able to supply the plaintiffs much longer, and advising the plaintiffs to make arrangements with some other electric supply company. On September 30 the defendants wrote again saying that they would continue to supply the plaintiffs until they were taken over by some other company. After that there were several complaints by the plaintiffs of decrease in the light, and on November 16 it failed altogether. Mr. Justice Stephen, before whom the case came, non-suited the plaintiffs, holding that there was no evidence of any contract to go to the jury, and that the defendants were only supplying the plaintiffs at will, and could at any moment stop the supply of electricity. The plaintiffs appealed.

Mr. Jelf, Q.C., and Mr. R. A. M'Call were for the appellants, and Mr. Lumley Smith, Q.C., and Mr. R. B. D. Acland were for the respondents.

The Court granted the application, and ordered a new trial of the action.

The **Master of the Rolls** said he thought the learned Judge had taken too strict a view of the matter. The question was whether there was any evidence which could go to the jury of any contract between the defendants and the plaintiffs for the supply of electricity. In his opinion there was such evidence, although he would not say that the jury must necessarily find that such a contract existed. There was evidence of an agreement between Pritchett and the plaintiffs which appear to have been adopted and acted upon by the defendants when they took over Pritchett's business. The case must therefore go for a new trial.

The **Lords Justices** concurred.

COMPANIES' MEETINGS.

CUBA SUBMARINE TELEGRAPH COMPANY.

Report of the Directors for the half-year ending 31st December, 1890:

The Directors beg to submit, duly audited, the balance-sheet and accounts for the half-year ended 31st December last. From these it will be seen that the gross receipts (including the balance brought from last account) amount to £21,325. 19s., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £6,759. 11s. 3d., leaving a sum of £14,566. 7s. 9d. to the credit of revenue account. Of this the sum of £4,450. 13s. 10d. has been added to the reserve fund, which now stands at £79,000. The dividend on the preference shares will absorb £3,000, and leave £7,115. 13s. 11d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance, £715. 13s. 11d., being carried forward to the current half-year's account. The new cable between Batabano and Cienfuegos, referred to in paragraph 6 of the last report, was completely laid on the 19th inst., but will not be taken over from the contractors until it has undergone the tests required by the contract. The instalments already paid have been deducted from the reserve fund, which will also be charged with the balance of the contract price. The Cienfuegos-Santiago 1881 cable broke down on 21st August last, and the 1875 one, between the same points, became interrupted on the 13th inst. The latter is now being repaired by the Company's engineer, the vessel which laid the new Batabano cable having been hired for the purpose, and the restoration of communication is daily expected. When this is accomplished the vessel will proceed to repair the 1881 cable, the cost of which has to be borne by Messrs. Hooper, the contractors. A special meeting has been convened to remedy a defect in the articles of association which is deemed to be necessary in the interests of the shareholders. With regard to the suit against the Spanish Government, the necessary forms for bringing the case under the consideration of the Contencioso Court are not yet complete, but it is expected that within a short time the case will be ready for hearing. The usual comparative statement of traffic is submitted herewith.

The thirty-ninth ordinary general meeting of this Company was held at the offices, 58, Old Broad-street, E.C., on Wednesday, the 11th inst., at 12 noon, Mr. Thomas Greenwood, chairman, presiding.

The **Secretary** having read the notice convening the meeting,

The **Chairman** said that the report and the accounts had been in the hands of the shareholders for some days, and he apprehended they had made themselves sufficiently acquainted with them, so that it would not be necessary to have them read. [The report is given above.] The incidents in the history of the Company during the last six months had been few and not of sufficient importance to be brought to their notice that day. They had gone on the even tenour of their way. Their income had increased—*i.e.*, they had made an improvement on the corresponding period of £1,450, while their expenditure had been increased about £250, which had been mainly caused by an unusual outlay on land lines; they had therefore about £1,200 increase. There had been no breaks in their cables during the past half-year, and therefore no expenditure upon repairs. This had enabled them to carry forward a much larger sum to the reserve fund, £4,450 after paying dividends, and a balance of £715 to next half-year. That was a satisfactory state of affairs. Their new cable between Batabano and Cienfuegos had been very successfully laid, and their reports were satisfactory. When the tests had been made he had no doubt they would find it was in perfect condition, and the balance of the purchase money would have to be paid. So far as this had been paid it had been taken out of the reserve fund, and the remainder would further reduce that fund. Still, it would leave them a considerable amount of reserve. There had been a break in the cable which had been in the hands of the contractors. The 1881 cable ceased to speak in August last, but, inasmuch as the contractors were about to go out to lay the new cable, they (the Board) did not press them to repair the broken one immediately, because they would have the vessel ready to do the business. Their 1875 cable broke last month, and they had used that vessel for the purpose of repairing it. He was glad to say that repair had been completed, and their line was in full working order. The 1881 cable was now under repair at the cost of the contractors, and they were expecting to hear every day that it was in perfect working order, when all their lines would be in that condition. There was one other item he had to go into, and that was the action they had against the Spanish Government. Their case had been under the consideration of their lawyers there, and had been very carefully drawn. It had been translated, sent over here and considered by the Secretary and himself, and had gone back with certain alterations to Spain. It would come on for hearing soon. He thought they had a good case, but there was always the glorious uncertainty of the law to be reckoned with. However, when they got the intelligence they would make the shareholders acquainted with it. He thought he had touched upon all the items, but would be glad to give any further information. He moved that the report and accounts for the half-year ending December 31 last be received and adopted.

This was seconded by **Mr. Low**.

In reply to a shareholder, the **Chairman** said that the above-mentioned action was brought under the following circumstances. The Spanish Government were about to grant a concession to their (the Company's) rivals—a French company—with the object of giving them the right to lay cables on the north side of the island, parallel to the Cuba Company's, which were on the south side. They (the Board) contended that that was a direct violation of the concession to them, and before the concession to the French company was granted they had taken action in the courts with a view of preventing it being done.

Mr. Griffiths asked as to the local and through traffic on their lines; what were the probabilities of each; and as to external rivalry?

The **Chairman** said they had no knowledge whatever of any variation likely to take place between the present relative income from the local and through traffic, though they might hope for an improvement in both. A cable had been laid from Halifax to Bermuda, but he knew nothing of that being continued to the island of Cuba. He then put the resolution, which was carried unanimously; as also was a resolution declaring dividends of 10 per cent. per annum on the preference and 8 per cent. on the ordinary shares.

This concluded the business of the ordinary meeting.

An extraordinary general meeting was then held to consider the following special resolution proposed from the chair and seconded by another Director—viz.:

"That the articles of association of the Company be altered by the addition of the following article, and the same is hereby adopted as one of the regulations of the Company:

"No person, not being a retiring Director, shall be eligible for election to the office of Director at any general meeting, unless he or some other member intending to propose him has, at least 21 clear days before the meeting, left at the offices of the Company a notice in writing under his hand, signifying his candidature for the office, or the intention of such member to propose him."

This, the **Chairman** explained, was moved in the interests of the shareholders, and in order that they might have notice of any change which any of them might desire to make in this direction. They had not got their full complement of Directors. They had only four out of the nine they could have. Four were quite sufficient for the work, and to increase the number would not benefit the Company, whilst increased fees would have to be paid. He then moved the above resolution, which was seconded by a **Director**.

Mr. Cochrane moved an amendment to the effect that that meeting considered any alteration in the articles of association undesirable and unnecessary.

This was seconded by **Mr. Griffiths**.

In putting it to the meeting, the **Chairman** remarked that they had gone on for 20 years with these articles, but they had got into days of competition, and they did not want to have any persons on that Board who might have interests in a rival company. No single member of that Board at that time had any interest in any other company which was antagonistic to that Company. Their only object in proposing the resolution was to protect the shareholders' interests. He then put the amendment, which was lost.

Mr. Cochrane thereupon proposed a further amendment, which was also lost.

And after further discussion the resolution put from the chair was carried, the days having been altered from 21 to 14, by 12 votes to three, the Directors voting in its favour.

A cordial vote of thanks to the Chairman was moved by **Mr. Cochrane**, seconded by **Mr. Griffiths**, and carried unanimously.

PORTRUSH ELECTRIC TRAMWAY COMPANY.

The annual meeting of the shareholders was held on February 2, at the offices of the Company at Portrush. The following Directors were present: Dr. Traill, F.T.C.D., chairman; Mr. C. M'D. Stuart and Mr. Wm. A. Traill, C.E.; Mr. Danl. Fall, jun., secretary and manager.

On the motion of **Mr. Stuart**, seconded by **Mr. Henry**, the seal of the Company was affixed to the register of shareholders.

The report of the Directors was then submitted, from which the following is taken: Your Directors beg to submit for the approval of the shareholders their annual report to December 31, 1890, which completes the eighth year since the line was opened for traffic. Your Directors are glad to be able to report another large increase in the passenger traffic in the year, the first-class passengers having increased to 8,943 from 7,847 last year, and 6,970 in 1888; and the third-class passengers having increased to 73,859 from 56,822 last year, and 48,370 in 1888—the total for the year being 82,802, with corresponding receipts amounting to £2,573. 19s. 5d., as against a total of 64,669, with receipts £2,038. 11s. 7d. in 1889, and a total of 55,340, with receipts £1,880. 6s. 10d. in 1888. The goods and mineral traffic amounted to 316 tons, compared with 323 tons in 1889, and the receipts have been respectively £41. 8s. 11d. and £37. 9s. 9d. The receipts for parcels and miscellaneous traffic have increased during the year from £43. 8s. to £77. 7s., so that the total receipts from the revenue account have been £2,698. 15s. 4d., as against a total of £2,114. 9s. 4d. in 1889. There has at the same time been a reduction on the expenditure side of the account, which shows a total of £1,687. 12s., as against £1,732. 10s. 9d. in 1889, and £1,929. 6s. 11d. in 1888. There is, consequently, a credit balance on the result of the year's working of £1,011. 3s. 4d., as against £381. 18s. 7d. in 1889, and £290. 5s. 5d. in 1888. This result has fulfilled the anticipations of the Directors stated in last year's report, and is traceable not only to the increase in the passenger traffic, but to the alteration made two years ago in the arrangements with regard to the goods traffic, which had previously been a constant source of loss to the revenue. It will be seen on an examination of the above figures that the ratio of expenses to receipts, which was 82 per cent. in 1889, has been reduced to 62 per cent. in the past year. The value of electricity as a locomotive power, when generated by water power, has been remarkably shown during the past year, owing to the great rise in the price of fuel for the steam engines. The expenses of the electrical working amounted to £272 for 20,884 miles run, or 3⅛d. per mile while steam power cost £707 for 11,286 miles run, or 15d. per mile. In 1889 the number of miles run by electrical and steam power respectively were 17,960 and 13,192, and the respective costs 6d. and 13½d. per mile, so that a change in the price of fuel has had a serious effect in the one case and none at all in the other. The cost of coke delivered in Portrush went up during the year from 26s. to 34s. 6d. per ton. The favourable state of the revenue account is, therefore, largely owing to the increased use of electricity as the motive power upon the line, with a corresponding reduction in the use of steam. The total mileage run shows an increase of 1,288 over the previous year, the respective numbers being 32,170 and 30,882. In dealing with the balance of £1,011. 3s. 4d. to credit of the revenue account, your Directors feel that they will have the approval of the shareholders in charging this balance with interest at 4 per cent. on £10,000 of £11,500 for the construction of the branch line to the Giant's Causeway. The net revenue account has, therefore, been charged with £400 interest on the above £10,000, and with £400 interest on the advance of £10,000 by the Board of Works. The rapid increase in Portrush from year to year is most favourable to the prospects of the Company, as that town provides a constant stream of visitors to the Giant's Causeway and the intervening coast scenery, while tourists from distant parts and the artisans from the manufacturing towns of Ulster will add a large contingent so long as the country generally is prosperous and agitation is crushed out by firm government. Your Directors have co-opted Mr. James Stewart Moore, of Ballydivity, as a director, in place of Mr. Atkinson, whose death they had to report at the last annual meeting. Sir William Thomson, F.R.S , and Dr. Traill retire by rotation, and are eligible for re-election.

Engineer's Report.—I have to report that the permanent way and works, electrical plant, engines, and rolling stock have been maintained in an efficient state during the past year. The anticipations in my last report have been verified. There has been a considerable reduction both in the working expenses and in the maintenance of the permanent way, although the total mileage has been greater than in any previous year, and I anticipate a still further reduction in the expenses in the ensuing year. The number of miles run by electricity has exceeded that of any year since the opening of the tramway—viz., 20,884 miles—worked at a cost of £271. 13s. 1d., or at 3⅛d. per mile, a lower rate per mile than has ever been attained before. The number of miles run by steam has been reduced to 11,286 miles, and they have been worked at a cost of £707. 7s. 5d., or at 1s. 3d. per mile run. From these figures, at once is apparent the enormous advantage of the electric motive power over the steam motive power, being about one-fifth the cost, mile for mile. Of the total 32,170 miles run, 28,166 miles—viz., 16,880 electric miles and 11,286 steam miles—were run during the six summer months, while only 4,004 miles, and these entirely by electricity, were run during the six winter months.

The report having been duly proposed and seconded, was passed.

Mr. Henry (shareholder) stated that he considered the report most satisfactory; that upon the year's working of the tramway there was an additional net gain of £629 above that of the preceding year, and that the total revenue gain of £1,011. 3s. 4d. was very gratifying, and that he looked forward to a prosperous future for the Company.

The usual vote of thanks being passed to the Directors, the meeting terminated.

COMPANIES' REPORTS.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY, LIMITED.

Directors: S. Wm. Silver, Esq. (chairman), Neil Bannatyne, Esq., Abraham Scott, Esq., Matthew Gray, Esq. (managing director), Robert Henderson, Esq., the Hon. Henry Marsham, A. Weston Jarvis, Esq., M.P.

Report of the Directors for the year ending December 31, 1890, to be presented at the twenty-seventh ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, London, on Thursday, February 19, 1891, at twelve o'clock:

The annexed accounts show the net profits for the past year to be £65,334. 11s. 2d. Adding £41,236. 6s. 8d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £85,770. 17s. 10d. The Directors have added £25,000 of this balance to the reserve fund (raising it to £300,000), and recommend the distribution of a dividend of 10s. per share, free of income tax, amounting to £20,800, making, with the interim dividend, a total payment for the year of 10 per cent., and leaving £39,970. 17s. 10d. to be carried forward. During the past year the Company has done a much larger general business than in any previous year, and a fair amount of cable work; but keen competition and increased cost of material continue to reduce the rate of profit. The works and machinery are maintained in a thoroughly efficient state. Mr. Bannatyne and Mr. Henderson, the directors retiring by rotation, offer themselves for re-election. Mr. Weise is re-eligible as auditor.

BALANCE-SHEET, 31ST DECEMBER, 1890.

Dr. *Capital and Liabilities.*	£	s.	d.
Amount of authorised share capital	812,000	0	0
Share capital—Amount subscribed and paid on authorised issue of 41,600 shares of £10 each	416,000	0	0
Mortgage debentures	200,000	0	0
Reserve fund	300,000	0	0
Steamers' maintenance fund	10,000	0	0
Debts owing by the Company	63,752	9	3
Unclaimed dividends	2	10	0
Proposed dividend, 5 per cent.	20,800	0	0
Amount carried forward to 1891, as below	39,970	17	10
	£1,050,525	17	1

Cr. *Assets and Expenditure.*	£	s.	d.
Freehold land, buildings, and machinery at Silvertown and at Persan, and steamships "Silvertown," "Dacia," "International," and "Buccaneer"	478,952	5	9
Freehold premises at Liverpool, and expenditure on Cannon-street premises	23,241	13	4
Debts owing to the Company	89,222	14	4
Cash with bankers and in hand	19,288	16	9
Bills receivable	1,894	17	6
Stock-in-trade, including cable on account of contracts	230,175	15	7
Debentures and shares in other companies	33,890	10	0
Cash, stock, etc., at Persan and other agencies	173,859	3	10
	£1,050,525	17	1

PROFIT AND LOSS ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Dr.	£	s.	d.
Salaries, interest, rent, rates and taxes, repairs and general expenses	60,358	3	11
Bad debts	384	16	3
Income tax	1,589	0	0
Depreciation written off buildings and machinery	14,337	0	0
Addition to steamers' maintenance fund	5,000	0	0
Directors' remuneration (minimum)	2,000	0	0
Balance—Profit for the year, carried down	67,971	14	8
	£151,640	14	10

Cr.	£	s.	d.
Gross profit, after charging commission, but including interest on debentures and shares in other companies	150,925	1	6
Income tax refunded	715	13	4
	£151,640	14	10

Dr.				£	s.	d.
Addition to reserve fund				25,000	0	0
Interim dividend of 5 per cent. paid in July	£20,800	0	0			
Proposed dividend of 5 per cent.	20,800	0	0			
				41,600	0	0
Balance to be carried forward to 1891				39,970	17	10
				£106,570	17	10

Cr.				£	s.	d.
Balance brought down	£67,971	14	8			
Less additional remuneration due to Directors after payment of 10 per cent. to shareholders	2,637	3	6			
				65,334	11	2
Amount brought forward from 1889				41,236	6	8
				£106,570	17	10

NEW COMPANIES REGISTERED.

Shropshire Electric Light and Power Company, Limited.—Registered by Chester and Co., 36, Bedford-row, with a capital of £25,000 in £10 shares. Object: to carry on the business of an electric light and power company. The first subscribers are:

	Shares.
T. S. Eyton, Walford Hall, Shrewsbury	50
J. A. Bratton, Shrewsbury	20
J. B. Lloyd, Hetton Hall, Shrewsbury	20
R. Maddox, Belle Vue, Shrewsbury	20
J. Lea, Coton-hill, Shrewsbury	20
J. C. Porter, 3, Princes-street, Shrewsbury	20
H. Robinson, Bottaloy, Merioneth	20

There shall not be less than five nor more than seven Directors. The first are T. Slaney Eyton, J. A. Bratton, R. Maddox, H. Robinson, and J. A. Lea. Qualification, £200. Remuneration, £100 divisible.

Telegraph Construction and Maintenance Company.—The Directors, subject to the audit of the accounts, propose paying a dividend of 15 per cent., £1. 16s. per share, in addition to the 5 per cent. already paid, making 20 per cent. for the year 1890.

CITY NOTES.

City and South London Railway.—The receipts for last week were £702.

West Coast of America Telegraph Company.—The receipts for January were £3,925.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £5,956.

London Electric Lighting (Pioneer) Company.—Letters of allotment and regret have been posted.

Great Northern Telegraph Company.—The receipts for January were £20,800, against £19,600 in the same month of 1890.

Eastern Extension Telegraph Company.—The receipts for January amounted to £46,575, as against £40,610 in the corresponding month of 1890.

Eastern Telegraph Company.—The traffic receipts for the month of January were £60,005, against £59,478 in the corresponding period of 1890.

Western Brazilian Submarine Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £4,858.

Cuba Submarine Telegraph Company.—The receipts for January were £2,400, as compared with £3,176. The decrease is owing to an interruption during the latter half of the month.

Edison and Swan United Company.—The Directors have decided to pay an ad interim dividend for the half-year ending Dec. 31, 1890, at the rate of 7 per cent. per annum upon the A shares, to be distributed in accordance with the articles of association. It is intended to issue the dividend warrants on the 20th inst.

Bell's Asbestos Company.—The Directors have resolved, in view of the audited accounts to the 31st of December, 1890, to recommend to the shareholders at the general meeting to be held on the 23rd inst. the payment of a dividend of 5s. per share, which, with the interim dividend paid in July, makes a total distribution of 15 per cent. for the year. The amount to be carried forward is £1,973.

PROVISIONAL PATENTS, 1891.

FEBRUARY 2.

1844. **Arm or elbow rests for telephonic purposes.** Joseph Slater Lewis, The Swifts, Yardley, near Birmingham.

1905. **An improved method of and means for distributing electric currents.** Llewelyn Birchall Atkinson, 1, Queen Victoria-street, London.

FEBRUARY 3.

1908. **Improvements in electrical switches.** David Maxwell, 87, St. Vincent-street, Glasgow.

1912. **An improved galvanometer or instrument employed for measuring, indicating, or detecting electric currents.** Joseph Slater Lewis, The Swifts, Yardley, near Birmingham.

1913. **An improved electric bell.** Joseph Slater Lewis, The Swifts, Yardley, near Birmingham.

1923. **Improvements in electrical switches.** Gustav Binswanger, 71, Queen Victoria-street, London.

1928. **Improvements in the method of and means for increasing the strength, volume or intensity of sound during transmission, applicable to telephones, microphones, phonographs, and other sound transmitting and emitting instruments and apparatus.** Charles Herbert Demuth, 1, St. James-square, Manchester.

1963. **Improvements in methods of and apparatus for electrically soldering cans and other sheet metal ware.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

1968. **Improvements in and relating to electric lamps or lighting apparatus.** Henry Harris Lake, 45, Southampton-buildings, London. (Frederick Victor Maquaire, France.)

1969. **Improvements in electrical signalling apparatus.** Henry Harris Lake, 45, Southampton-buildings, London. (Samuel Jason Burrell, United States.) (Complete specification.)

1987. **Improvements in electric lamps.** Alexander Melville Clark, 53, Chancery-lane, London. (James W. Easton, United States.) (Complete specification.)

FEBRUARY 4.

1994. **An electric light lamp shade.** Georgina Belt, Parliament-mansions, Victoria-street, London.

2009. **Electric thief and fire-alarm** Emanuel Berg, Link-strasse 29, Berlin.

2033. **Improvements in dynamo-electric machines.** William Lowrie and Robert Hammond, 433, Strand, London.

2040. **Improvements in switches for secondary batteries or accumulators.** Hermann Müller, 45, Southampton-buildings, London.

2045. **Electrical ore stamping and pulverising apparatus.** Richard Richardson Hutchinson, 11, Furnival-street, London.

2046. **Improvements in and relating to electrically propelled vehicles especially adapted for high rates of speed.** Richard Richardson Hutchinson, 11, Furnival-street, London.

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2061. **Improvements in electric lamp holders.** William Phillips Thompson, 6, Lord-street, Liverpool. (Joseph Benjamin Moore, United States.) (Complete specification.)

2067. **Improvements in electrical transformers.** Casper Baur and Wilhelm Dieselhorst, 28, Southampton-buildings, London.

2081. **Improvements in or relating to multiple circuit telegraphy.** Charles Adolph Gisborne, 77, Chancery-lane, London. (David Herbert Keeley, Canada.)

FEBRUARY 5.

2115. **Improvements in or connected with metallic gauze brushes employed in dynamo-electric machines.** Joseph Dean and Charles Jubb, Commercial-street, Halifax.

2152. **Improvements in electric switches.** James Cowan Woodburn, 96, Buchanan-street, Glasgow.

2155. **Improvements in armatures for dynamo-electric machines.** John Nebel, 28, Southampton-buildings, London.

FEBRUARY 6.

2180. **Improved means or appliance for fixing or driving staples or like devices, especially applicable to electric fittings.** George Thomas Mackley, 17, Southampton-buildings, London. (Carl Mackley, Germany.)

2199. **Improvements in automatic electric switches** Charles Walter Cox, Frederick Robinson, and William Henry Gritton, 6, Lord-street, Liverpool.

2200. **Improvements in or relating to electromotors.** Edward Attenborough, 323, High Holborn, London.

2201. **Improvements in laying and insulating underground mains for carrying electricity.** James Ernest Spagnoletti, 2, Great George-street, Westminster, London.

2219. **Improvements in electric arc lamps.** Emily Eliza Lever, 77, Chancery-lane, London.

2221. **Improvements in and relating to machinery for covering telegraph and telephone cables and wires with lead or other metallic compounds, also applicable for the manufacture of metal pipes and the like.** George Edward and Thomas Edward, 96, Buchanan-street, Glasgow.

2225. **Improvements relating to motors for electric railways.** J. B. Berlier, 45, Southampton-buildings, London.

FEBRUARY 7.

2289. **Electrical block signalling apparatus for single line railways.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany.)

2293. **An improved cut-out fuse.** William Wilson Horn, 151, Strand, London. (George Herbert Whittingham, United States.)

2297. **A method of and apparatus for prolonging the life of the carbons in electric arc lamps.** Charles Walter Hazeltine, Norfolk House, Norfolk-street, Strand, London. (Date applied for under Patents Act, 1883, Sec. 103, 9th July, 1890, being date of application in United States.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1888.

12593. **Recording and reproducing sounds.** Gouraud (Edison). 1s. 1d. (Second edition.)

1889.

20486. **Distributing electricity.** Pritchett and Low. 6d.

1890.

911. **Electrical conductors.** Pitt (Atherton). 8d.
993 **Incandescence electric lamps.** Edmundson and Clarke. 8d.
1072. **Electrical switches.** Binswanger. 6d.
2153. **Telephone switchboards** Dewar. 8d.
2654. **Electric cables.** Kingsbury (Western Electric Company). 8d.
2655. **Insulating electric wires.** Kingsbury (Western Electric Company). 8d.
2845. **Secondary batteries.** Mackrill. 4d.
3913 **Alternate current transformers.** Kapp and others. 8d.
13557. **Secondary batteries.** Dixon. 8d.
18638. **Electricity meters.** Hartmann and Braun. 8d.
19155. **Electrical storage batteries.** Lake (Hatch). 6d.
20019. **Electric railway circuits.** Sabold. 6d.
20612. **Incandescent electric lamps.** White. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	1½
Swan United	3½	5
St. James'	—	6
National Telephone	5	4¾
Electric Construction	10	7¼

NOTES.

Extension at Vienna.—The central station in Kaunitzgasse, Vienna, is to be extended, to comply with the increasing demands of customers.

Pacific Cable Rates.—The Eastern Telegraph Company will reduce their rate in 15 days after the Australian Government have accepted the conditions proposed.

Lost Children.—The latest telephone scheme is the organisation of a "lost child" telephone service, which in some towns has, it appears, given good proofs of usefulness.

Overhead Wires. — The London County Council General Powers Bill and the Overhead Wires Bill have been postponed till to-day, with a view to modification in some of the provisions of the measures.

Honolulu Cable.—The Naval Appropriation Bill, as amended last week by the United States Senate, appropriates a sum of 25,000dols. for soundings for a cable between San Francisco and Honolulu.

Eisenach.—The Allgemeine Company of Berlin, which has undertaken the establishment of an electric central station for Eisenach, has invited applications for capital for a third of the 300,000 marks, the estimated first cost for the plant.

Electrotechnics in Germany. — In the technical college at Darmstadt there were in 1890, out of 339 students, 97 electrical students against 48 architects, 46 engineers, 67 builders, 54 chemists, and 25 mathematicians and naturalists.

Cannes.—The Société d'Eclairage Electrique de Cannes has been formed in Lyons with a capital of 1,100,000f., divided into 2,200 shares of 500f. each. The object of the company is to supply electric light and power in Cannes and neighbourhood.

Edison Company.—It is stated that there is good reason to believe that the Vanderbilts have bought a large interest in the Edison General Electric Company, and rumour states the purchase at from 10,000 to 15,000 shares. The capital stock of the company is 13,000,000dols.

Ipswich.—At their last meeting, and after considerable discussion, the Town Council rescinded that part of their previous resolution which refused assent to the Ipswich Electricity Supply Company. Mr. A. Cattermole gave notice that at the next meeting he would move to rescind the rescinding resolution.

Nuremberg.—The Allgemeine Company are erecting a central station at Schnilling for the purpose of lighting the villages around Nuremberg. In each of these a sub-station will be placed, to afford independence of the centres of distribution. The price will be 1d. per 100 watt-hours, with a 5 per cent. reduction above a certain quantity.

Walsall.—The General Purposes Committee of the Walsall Town Council at the last meeting reported that they recommended the employment of Mr. F. Brown, of the Walsall Electrical Company, to advise with the Electric Lighting Sub-Committee, it being incumbent upon the Council to light a certain area by electricity within two years.

Compensation.—An action brought, before Mr. Justice Lawrance, against the City and Southwark Subway Company by the executors of Mr. J. F. Lovering, to recover £3,083 award for damage by the defendant company, was not held to be good upon grounds of wrong description of the lawful possessor, and judgment was given for the defendants with costs.

Brighton Grand Hotel.—The ordinary general meeting of the Brighton Grand Hotel was held on Wednesday at the City Terminus Hotel. Mr. W. Sharp, in moving the adoption of the report, stated that they had themselves now established an installation of the electric light at a cost of £6,000. They anticipated a considerable saving under this heading in the future.

Aberdeen Infirmary and Asylum.—At the annual meeting of the Aberdeen Royal Infirmary and Lunatic Asylum Corporation held last week, under the presidency of Lord Provost Stewart, Mr. J. Dove Wilson, LL.D., spoke in favour of the introduction of electric lighting into the institution, mentioning the success which had attended its adoption in the Victoria Hospital, Glasgow.

Cheltenham Theatre.—A new theatre and opera house at Cheltenham is to be built, and the tenders of Messrs. Bradney and Co., Wolverhampton, are accepted. It should be worth the while of electrical engineers to see that the electric light is introduced and provided for at an early stage. The address of the architect is Mr. F. Matcham, 3, Great James-street, Bedford-row, W.C.

Society of Arts.—The second of the Cantor lectures on "The Electric Transmission of Power," by Gisbert Kapp," will take place on Monday, February 23, at 8 p.m. Syllabus of Lecture II.: Transmitting Live Power—Fundamental Principles—The Dynamo and Electromotor—Regulating Appliances—The Line—Best Section of Conductor—Cost of Plant and Working Expenses—Examples.

New South Wales.—On January 1, at Newcastle, New South Wales, the official installation of the electric light took place. The installation will cost £9,000, and the contractors work the system for a period of 12 months. There are 360 incandescent lamps and 22 arc lights. It was pointed out at the ceremony that Newcastle is the first city in Australia to be entirely lighted by electricity.

The Royal Naval Exhibition.—The work at the Royal Naval Exhibition is progressing. The water-basin, the "Victory," and the different buildings are being pushed on. Capt. Wilson, V.C., of Her Majesty's ship "Vernon," has sent up some most valuable suggestions relative to the working of electric models on the water-basin, which will add another interesting item to those already thought of.

Glasgow Tramways.—The Glasgow Tramway Company have lodged a petition in the House of Lords against the Glasgow Corporation Bill *re* tramways. They object as future competitors to additional powers being granted to the Corporation, and maintain that the application of electricity to tramways is yet in its infancy, while much experience is required before its application to Glasgow can be said to be expedient.

Canterbury.—The question of electric lighting came before the Canterbury City Council last week. The Brush Company's offer was considered, and the lighting of the cathedral was alluded to, it being understood than the Dean and Chapter thought the initial cost far too large. The motion to accept the Brush Company's offer was not seconded, and eventually a committee was appointed to consider the proposed provisional order.

Simple Tester.—A little handy tester for linesmen, a modification of a well-known experiment, has been designed thus: a penny block of indiarubber has two plates of brass fastened thereon on each side, a strip of zinc and a shilling can be slipped under between brass and the rubber, while from the plates two leading wires are taken. Tests of continuity can then be taken by connecting the wires to the circuit and touching the two metals with the tongue.

Leamington.—The resolution has been carried by the sub-committee of the Leamington Town Council to discontinue the contract for lighting certain public streets. It was stated that the illumination had tested to only 10·3 candles. In the matter of further electric lighting, they agreed to be under the advice of the clerk, who had instructions to obtain a provisional order for lighting the borough, and the committee would not interfere with his position in any way.

Royal Society of Edinburgh.—The sixth ordinary meeting of the session of the Royal Society of Edinburgh took place on Monday, Sheriff Forbes Irvine presiding. Prof. Cargill G. Knott sent a note on a recent paper by himself on the interaction of longitudinal and circular magnetisation in iron and nickel wires. Prof. Tait, who read the note, said it raised a curious question as to the extraordinary influence of a very slight twist in the wire upon the results obtained from it.

Vienna.—There are now four electrical companies competing with each other in Vienna. These are the lately formed Austrian General Electric Company and the International Electric Company, the Vienna Electric Company, and the International Air and Electric Company. The last named exploits the Popp system. The Vienna Municipal Council have granted a concession to the Popp Company for distribution by compressed air and electricity. The central station will be commenced shortly.

Patent Office.—Sir Michael Hicks-Beach in the House of Commons stated that the abridgments for the subjects of electricity, acids, alkalis, oxides and salts, and benzene and carbon derivatives have been published up to 1876; and as regarded the period between 1877 and 1883, the bulk of them have been made and are now in course of printing. The subject matter index for 1856 to 1883 is out of print, but it has been widely distributed. For the future, its place will be taken by indexes to abridgment classes.

The Jarman System.—A practical demonstration of the Jarman system of electric traction is intended to be undertaken shortly on one of the tramway company's lines at Clapham. The system is being promoted by the Electric Tramcar Syndicate, Limited, who have already acquired a depôt in High-street, Clapham. There are now ready for placing on the lines two cars which are self-contained or accumulator cars, similar in appearance to those running on the Barking line of the North Metropolitan Tramway Company.

Electric Light in the Holy Land.—A decided sensation has been caused in Jerusalem by the introduction of electric light into a new and flourishing flour mill lately started there. The building in which the light has been introduced is near to the supposed site of Calvary, and close to the Damascus Gate. It need hardly be said that the Arabs and Jews are much puzzled to account for a light in a lamp in which there is no oil, and up to the present time, while gazing with wonder, have been keeping at a respectful distance.

Peroxide of Lead.—To cover iron and steel with a layer of peroxide of lead, Mr. Haswell, of Vienna, plunges the objects to be coated in a bath composed as follows:

Nitrate of lead	·8
„ ammonia	2
Water	100

The objects are connected with the positive pole of a source of electricity giving ·2 to ·3 amperes of current. Mr. Haswell has patented this process, but we do not quite see its utility.

Sunderland.—A special meeting of the Sunderland Council was held on Monday for the purpose of passing a resolution to apply to the Board of Trade for a provisional order for the supply of electricity within the borough. Alderman Pecket, in the absence of the Mayor, presided. Alderman Bell, in moving the resolution, said the deposit of £50 to cover the cost of the order had been lodged, but, if there should be any opposition, the expenses would probably be larger. Alderman Wilson seconded the motion, which was carried unanimously.

Meresole's Dry Battery.—To make the composition in this battery, mix intimately in a dry state—carbon, three parts; graphite, one part; binoxide of manganese, three parts; slacked lime, one part; arsenious acid, one part; glucose or dextrine, one part. This mixture, when finely pulverised, is then commingled with a saturated solution of sal-ammoniac and sea-salt, strengthened by one-tenth of its volume with a solution of bichloride of mercury and an equal quantity of hydrochloric acid. When this has been thoroughly mixed, the paste can be placed in a cell and sealed.—*Bulletin International de L'Electricité.*

Glasgow Art Museum.—Mr. James Paton, curator of the Corporation Art Galleries, read a paper the other day giving a sketch scheme of the proposed Glasgow Art Museum, for which a site has been granted. In his remarks upon the light, it should be admitted, he said, at as low a level as possible, and he instanced the galleries of the "Sheepshanks Collection" at South Kensington as answering satisfactorily the requirements. The incandescent electric light afforded a means of illuminating a picture gallery practically free from every objection which could be urged against an artificial system of lighting.

South Kensington Subway. — In the House of Commons on Thursday last week, the Bill for the South Kensington and Paddington Subway was read a second time. Mr. Baumann stated that the Bill was one to construct a railway from Bishop's-road, Paddington, underneath Kensington Gardens to the Albert Hall. Mr. T H. Bolton moved that the committee consider the insertion of a clause to provide that a certain share or royalty after a fair interest had been earned should be set aside as compensation for underground rights, but after discussion and a statement on the law of the subsoil, the motion was by leave withdrawn.

A Useful Book.—We have received the eighteenth edition of Spon's "Architects and Builders' Price Book" (1891), by W. Young. Besides the usual information as to building materials, ironwork, plumbing, glazing, etc., we have this year a chapter devoted to electricity, in which the author gives complete specifications and estimates for lighting installations as carried out by him. These include a country house (isolated plant), a town house (supplied from a central station), and a London bank (isolated plant using gas engines). The book is published by Messrs. Spon, 125, Strand, and will be found of practical utility to electrical engineers.

City and South London Subway.—The siding accommodation of the South London electric railway has been found insufficient, and arrangements are now in progress for the construction of additional sidings at Stockwell. On the recommendation of the Board of Trade, a fourth engine and dynamo is to be added to the generating plant at Stockwell depot, and it is intended also to add two additional trains and four additional locomotives to the rolling-stock. As soon as these additions are complete, it will allow of a considerable accession to the number of trains run, and the opening of the line on Sundays, if thought desirable.

Gaseous Fire Extinguisher for Telephone Exchanges.—Fires at the back of telephone switchboards are not uncommon, and has become with the overhead wires for electric railways in America so great a source of trouble that an automatic fire extinguisher has been devised by Mr. J. J. O'Connell, electrician to the Chicago Telephone Company. The action of the extinguisher is based upon the fact that carbonic acid will extinguish fire and will not affect insulation. A tank is filled with a solution of soda in water, over which an open vial of sulphuric acid is suspended; the mixture when set off on occasion of an accident, forms carbonic acid and the pressure is utilised to play upon the flames.

Leeds.—A meeting of the members of the Parliamentary Committee of the Leeds Corporation was held last Friday, Alderman Harrison presiding, for the purpose of hearing the representatives of the electric lighting companies which have applied for powers to supply the borough with the light. These are the Electric Installation and Maintenance Company, the Yorkshire House-to-House Supply Company, Limited, and the National Electric Supply Company, Limited. The proposals submitted by the representatives of the companies were discussed at great length, and the meeting was adjourned. A meeting will subsequently be held in order to arrive at a decision as to which of the companies the committee will recommend to the Council to supply the light.

Electric Alarms for Colney Hatch.—The Asylum Sub-Committee of the London County Council report that the only existing electrical communication in the buildings at Colney Hatch (which cover an area of eight acres) is the electric fire alarm. This is not sufficient, and it is often necessary to communicate by other means, by messengers, with the medical and other officers, which involves delay. The cost of providing this additional electrical communication is estimated to be £400. They are of opinion that these works should be carried out, and therefore recommend that subject to an estimate being submitted to the Council by the Finance Committee as required by statute, that they should be authorised to provide electrical communication at Colney Hatch Asylum.

The Fire at Cardiff.—It having been suggested that the fire at the Marquis of Bute's recent mayoral banquet might be due to gas, and not to the electric light, Mr. W. H. Massey, of Twyford, engineer in the Queen's Household, was asked to report upon the matter. He finds that there was no gas burner within 15ft. of the point where the fire broke out, and that the accident was undoubtedly caused by electricity. One of the electric collar-holders became overheated by an arc at the inside terminals, and this set fire to the tissue paper decorations which improperly surrounded the fittings. The roof of the drill-hall in which the banquet was held has been slightly scorched in places, but the building itself has sustained no damage, although some valuable family paintings were destroyed.

Cardiff.—At the meeting of the Parliamentary Committee of the Cardiff Corporation, the town clerk, with reference to the Cardiff Electric Lighting Bill, read a communication from Mr. J. A. Corbett, on behalf of Lord Bute, the Bute Docks Company, and the Glamorganshire Canal Company, embodying certain amendments, which he asked the committee to insert in the electric lighting order. Alderman Carey remarked that the object of the amendments was simply for the protection of the Bute and canal company's property; and they were adopted. The town clerk stated that opposition to the electric lighting order also came from the Taff Vale Railway Company and the Cardiff Gas Company, but the latter body in its original objections practically admitted the necessity for the Bill being promoted by the Corporation.

Telegraphic Communication between Bradford and America.—In the course of another week or so Bradford will be placed in possession of a direct cable service with America. Premises on the ground floor of the Midland-buildings, Forster-square (near the General Post Office), have been taken for the purpose, and workmen are at present engaged in putting in the requisite appliances. This arrangement is due to the large number of cable messages, chiefly of a commercial character, which daily pass between Bradford and the United States. Recognising the probability of an increase of such messages, the Government, in conjunction with the Commercial Cable Company (the Mackay-Bennett cable), have decided to provide direct communication from Bradford, *viâ* Liverpool, to Valencia, in the South of Ireland, the cable station for the Mackay-Bennett cables.

Birmingham Town Hall.—The Estates Committee of the Birmingham City Council have had before them the question of certain improvements in the Town Hall. With reference to lighting, they report that the committee have come to the conclusion that while retaining the use of gas in the hall, provision should be made for a proper installation of electric light. They have had before them some estimates of the number of lamps required, and they propose to take the necessary steps for carrying the installation into effect, the disposition of light and designs for lamps, electroliers, etc., being submitted to Messrs. Cossins and Peacock, in conjunction with the firms employed to do the work. The probable cost of the foregoing is estimated by the committee as follows: Entrances and staircases, stairs and alterations to basement, additional staircases from orchestra, firemen's staircases, etc., £3,767; heating and ventilation, £1,000; electric lighting, £1,200; total, £5,967.

Electric Plumbing.—A series of articles has been started in the *Plumber and Decorator* entitled "Electric Plumbing" by "Volt," to give an elementary insight into electric fitting. The author strenuously disclaims any idea of instigating the plumber to attempt to become an "electric engineer," or any intention of endeavouring to instruct him how to become one, but thinks that many country plumbers will be thankful for plain, practical instructions in electric bell fitting, and sufficient information *re* electric lighting to enable them, at least, to step into the gap where there has been a breakdown, and do a little ordinary repairing. A plumber can make a good soldered joint, and with some knowledge of electrical principles it is thought might become a good electric wireman. The tendency of the time lies in this direction, and the organ of the plumbing industry is no doubt well advised to induce its readers to turn their attention to electric light—always of course under the proper superintendence of a properly qualified electrical engineer.

Glasgow Lighting.—Before the Glasgow Police Commissioners on Monday, Mr. Gray mentioned that the Watching and Lighting Committee had directed the inspector of lighting to make enquiry as to the towns in which the electric light was used, and to report. He explained that they were not desirous of doing anything which would interfere with the interests of the Gas Committee. Mr. Ure, the convener of the Gas Committee, approved of their action, and explained that all that was wanted was to learn what was being done elsewhere, as to the lighting of streets with electricity, particularly in England. If it were found that the streets could be more efficiently lighted by electricity than by gas, the Gas Committee would not stand in the way. The committee would be glad to get all the information they could. Mr. Primrose said it was understood that in the metropolis electric lighting companies were having districts allocated to them. Proceedings in regard to electric lighting were being taken in many places, conspicuously in Leeds. The committee desired to know the merits of the various systems.

The London Library.—Both by its traditions and its popularity, the London Library in St. James's-square is virtually a public institution, and its committee is therefore properly subject to public criticism. The *Pall Mall Gazette* criticises it in a friendly manner, and wants to know why the committee of the London Library has not yet adopted the electric light. The mains of one of the lighting companies run past the door, and an institution that devotes nearly £1,000 a year to the wiping off of debt could easily spare a couple of hundred pounds for the installation and fittings. A library is a place where the electric light is more wanted than almost anywhere else, for books suffer horribly from gas. And the gas in the London Library is specially bad. Both readers and attendants complain of the bad light and the hot, stuffy atmosphere. Such an obvious improvement as the introduction of the electric light ought not to be delayed any longer. The extra expense incurred for lighting will soon be recouped to the funds of the library by the reduction of the binding bill, and by the increased efficiency of the staff.

Yarmouth.—The Electric Lighting Committee of the Yarmouth Town Council reported that they had considered the electric lighting provisional order obtained in the last session of Parliament by the Council, and a report was read showing that in nearly all the other towns in which provisional orders had been obtained nothing had been done further than to appoint committees to report upon the subject. It was resolved to recommend the Council to let the matter of lighting the main streets of the town with electricity stand over till July next, when the committee would again report on the subject. The town clerk and the borough surveyor were directed to supply the committee, in July next, with reports upon the electric lighting carried out in other towns to that date. The Council were recommended to pay the following charges in connection with the Great Yarmouth electric lighting provisional order: Sharpe and Co., parliamentary professional costs, £127. 16s. 6d.; costs out of pocket, £121. 8s. 2d.; (£249. 4s. 8d., less paid on account, £100) £149. 4s. 8d.; town clerk, professional costs and payments, £46. 18s. 4d. The report was adopted without discussion.

Welding Glass and Porcelain to Metals.—M. Cailletet has communicated to the Société de Physique a method of welding glass and porcelain with metals, which may prove extremely useful for instruments of research, or for any metallic fitting, such as taps, communicating tubes, conducting wires, etc., so as to avoid all leakage even under high pressures. The process of welding is of the simplest. A portion of the tube that is to be welded is covered with a very thin coat of platinum. To obtain this deposit, it is sufficient to paint, by the means of a small brush, the slightly warmed glass with completely neutral chloride of platinum, mixed with essential oil of camomile. The essence is made to evaporate slowly, and when the white and coloured vapours have ceased to be given off, the temperature is raised to dull red heat, and the platinum being reduced covers the glass tube with a brilliant metallic coating. Connecting the tube thus metallically coated to the negative pole of a battery of suitable energy, it is placed in a bath of sulphate of copper. A ring of copper is deposited upon the platinum, and strongly adheres thereto if the operation has been properly carried out.

London County Council.—The Highway Committee of the London County Council have considered a notice, dated Feb. 2, 1891, from the London Electric Supply Corporation, of intention to lay mains in Whitcomb-street, Spur-street, and Leicester-square (one plan). It is intended to lay the mains in 3in. cast-iron pipes, the mains themselves being lead-covered concentric cables. They see no objection to what is proposed, and recommend: "That the sanction of the Council be given to the works referred to in the notice, registered No. 158, dated Feb. 2, 1891, of the London Electric Supply Corporation, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the works in any thoroughfare; that the mains be laid under the footways, and be kept 9in. below the under side of the paving, wherever it is found practicable to do so; and that where the mains cross the carriageways they be kept at the same depth below the concrete, or the road material, as the case may be." They have also considered a notice, dated 9th February, 1891, from the Kensington and Knightsbridge Electric Lighting Company of a proposed extension of mains in Ennismore-gardens (one plan). These works are of the ordinary character, and they recommend: "That the sanction of the Council be given to the works referred to in the notice."

Electro-Harmonic Society.—The next concert of the Electro-Harmonic Society will be a ladies' night, on Friday next, the 27th, at the St. James's Hall Restaurant (Banquet-room), Regent-street, at eight o'clock. Artistes: Miss Margaret Hoare, Miss Violet Robinson, Mr. Henry Guy, Mr. Bantock Pierpoint, Miss Frances Thomas, Mr. Alfred Izard; musical directors, Mr. T. E. Gatehouse and Mr. Alfred Izard. Programme.—Part I.: Trio, "Ti Prego" (Curschmann), Miss Hoare, Miss Robinson, and Mr. Henry Guy; song, "The lass that loves a sailor" (Dibdin), Mr. Bantock Pierpoint; song, "Bel Raggio" (Rossini), Miss Margaret Hoare; clarinet solo, Miss Frances Thomas; song, "The sailor's grave" (Sullivan), Mr. Henry Guy; lieder, "Geständniss," and "Du Fragst mich Täglich" (Helmund), Miss Violet Robinson; humorous selection. Part II.: Piano solo, "Ballade in G minor" (Chopin), Mr. Alfred Izard; song, "Where the Bee sucks" (Dr. Arne), Miss Margaret Hoare; new song, "Three Knights of old" (Boscovitz), Mr. Bantock Pierpoint; clarionet solo, Miss Frances Thomas; old French air, "Marguerite," Miss Violet Robinson; serenade, "Stars of the summer night" (Lassen), Mr. Henry Guy, humorous selection. With such a programme before them we hope every member who can do so will attend and afford the same pleasure to the ladies.

Shrewsbury.—At the Shrewsbury Town Council meeting the town clerk read a communication from the Shropshire Electric Light and Power Company, giving notice of their intention to apply for a provisional license to authorise them to supply electricity for public and private purposes within the borough, and asking the consent of the Council. Alderman Southam, in moving that the subject of electric lighting should be referred to a committee, said he did not like to see their good old town in any way lagging behind other towns. He thought the time had arrived when this question of electric public lighting would have to be taken up practically by all boroughs. Ludlow was, he noticed, about adopting it for the lighting of its streets, and he certainly should not like Shrewsbury to be behind Ludlow. He, therefore, would ask the Council to approve the reference of the question to a committee of the whole Council, in order that it might be fully considered. When such committee presented their report, the Council would be in a better position, with fuller information, to enter into a discussion of the question. He alluded to progress in Bradford and London, and proposed that the question of electric lighting in Shrewsbury should be referred to a committee of the whole Council to consider and report as early as possible to that Council with respect to it. Councillor Williams suggested the inclusion in the motion of the words "and the application of the Shropshire Electric Light and Power Company." Alderman Southam expressed his readiness to accept the suggestion and add it to his motion. The motion was amended accordingly, and agreed to. It was understood that the committee would meet within the next few days.

Preservation of Accumulators.—M. Gaston Roux, demonstrator at the Government Ecole de Physique et Chimie of Paris, has made a series of experiments to establish the conditions under which accumulators are best preserved when they remain a certain time without current being drawn therefrom. According to M. Roux, the most practical method is to charge them to saturation and then leave them to themselves. Trials were made with two Julien accumulators of 200 ampere-hours—part of a battery which had been serving for more than a year for experiments in the laboratory. The liquid of these accumulators is covered with a layer of paraffin wax, which was pierced with a small hole to permit thé gas produced in charging to escape. The containing cells are of glass, and are charged upon oil insulators. The solution, which contained 4 per cent. of sulphate of soda, had a density of 1·2 when the accumulators were charged to saturation. The two cells in question were charged on the 5th and then discharged on the 6th of August last, until their pressure was 1·8 volts. They furnished in this discharge 233 ampere-hours. On the 7th August they were again charged under the same conditions, and then left intact until 20th October. On this date they were discharged under the same conditions as on the 6th August, and 220 ampere-hours were taken out. As it must be admitted that the accumulators had received on the 5th and 7th the same quantity of electricity, it results that they only lost 13 ampere-hours—that is, 6 per cent.—during the 2½ months for which they were left to themselves. It may be said, as a general conclusion, that well-formed cells, well insulated, preserve their energy perfectly without being used, when the precaution is taken of charging them to saturation before being left to themselves.

Magnetic Rotation.—Before the Chemical Society a paper on "Magnetic Rotation" was read by Prof. W. Ostwald, of which the following is the abstract: "The magnetic rotation of organic compounds, according to Perkin, is an additive function of their composition and equal to the sum of the rotations of the components, but this is not the case with the rotation of inorganic compounds, which is usually found greater than that calculated on such an assumption. In the case of hydrogen chloride, for instance, the calculated value is about 2·18, and as a matter of fact the value obtained for hydrogen chloride dissolved in an organic solvent, isoamyl oxide, is 2·24, but when disolved in water the value found is from 4·05 to 4·42, increasing with the dilution. The author points out that these exceptional values are only obtained in the case of electrolytes, and that they must therefore be referred to a fundamental difference existing between the constitution of electrolytes and that of non-conductors. That such a difference exists has been already deduced from other considerations, and has led Arrhenius to the formulation of the theory of electrolytic dissociation. The author claims that the facts established with regard to magnetic rotation are in perfect accordance with this theory, and that any exceptional values in the magnetic rotations of electrolytes are due to the occurrence of electrolytic dissociation. In the discussion, Mr. Pickering said that in Prof. Ostwald's attempt to appropriate Dr. Perkin's results on the magnetic rotation of solutions of electrolytes in support of the dissociation theory, no attempt was made to explain what connection should exist between the magnetic rotation and the supposed dissociation into ions, but it was boldly stated that if, as in the case of hydrogen chloride, the magnetic rotation and dissociation both increased with dilution, the result proved the truth of the dissociation theory, while equal support to this latter theory was afforded if, as in the case of sulphuric acid, dilution diminished the rotation and increased the dissociation; and the most astonishing part of the argument appeared to be that the nearly double magnetic rotations obtained in some cases should be brought forward as a proof of dissociation, when the observations were made on solutions so strong that the dissociation theory represents them as containing hardly any dissociated substance at all. Surely the natural conclusion to draw from such a doubling when it occurs in the absence of dissociation would be that it could not be explained by dissociation.

Electrical Standardising Conversazione.—On Monday evening a *conversazione* was held by invitation of Mr. Hammond to view the Electrical Standardising, Testing, and Training Institution, at Faraday House, at the bottom of Charing Cross-road. The institution carries on the work of the old Hammond College, discontinued some years ago, but now considered necessary again by the rapid advance of electrical practice. Faraday House is a fine six-storeyed building, consisting of laboratories, workshops, lecture and class rooms, with engines and dynamos fitted in the basement. The laboratories are supplied with elaborate sets of testing instruments, including Sir William Thomson's ampere balances. The instruments, for a reasonable fee, will be placed at the disposal of experimenters. The work of training will be carried on by a competent staff, under the direction of Mr. H. E. Harrison, B.Sc. Some 500 visitors were received at the *conversazione* by Mr. and Mrs. Hammond, amongst those present being: Lord and Lady Castletown, Lord Russell, Sir Henry Mance, Sir Henry Cartwright, the Hon. Reginald Brougham, the Attorney-General, Prof. Kennedy, Prof. Riley, Prof. Forbes, Prof. Foxwell, Mr. W. H. Preece, Mr. Spagnoletti, Mr. Ferranti, Mr. Kapp, Mr. and Mrs. Langdon-Davies, Mr. and Mrs. Robert Fleming, Mr. F. H. Webb, Mr. William Lowrie, Mr. and Mrs. Powers, Mr. William O. Smith, and Dr. Robson Reece. The Earl of Crawford, chairman of the board of control of the institute, was prevented by indisposition from being present. Besides a very elaborate musical programme a large number of interesting electrical exhibits were provided. Visitors were much interested in seeing the phonopore, the invention of Mr. Langdon-Davies, in actual working order, sending duplex messages one in each direction along the wire already in use for Morse instruments, the minute induced currents being sufficient to vibrate a strained steel reed acting as relay switch for special telegraphic instruments, but not affecting the ordinary instruments. Messages in Morse letters were sent in triplicate and simultaneously for those desiring a practical test. Another interesting exhibit was Willis's electric ship-signalling apparatus, with Spratt's electric speed indicator, and Granville's new electric log, which dispenses with insulation on the tow line or the use of battery, all shown by Messrs. Elliott Bros. The Post Office sent an exhibition of telegraphic apparatus. The General Electric Company and the Electrical Supplies Company sent electric lighting fittings. Messrs. S. Z. de Ferranti and Co. and the House-to-House Electric Supply Company showed transformers, meters, and fittings of their respective systems.

UNDERGROUND MAINS.—IV.

THE CALLENDER SOLID SYSTEM.

(Continued from page 163.)

We now come to an interesting point, the connection of feeders, mains, and service lines.

In connecting the mains together, two different methods have to be considered: (1) those in which the joint is solid, permanent, and covered in with insulation in the same manner as the rest of the cables; and (2) those in which the connections of feeders to distributing mains and of those to house service mains are sometimes required to be altered or disconnected easily, either for change of load or for testing.

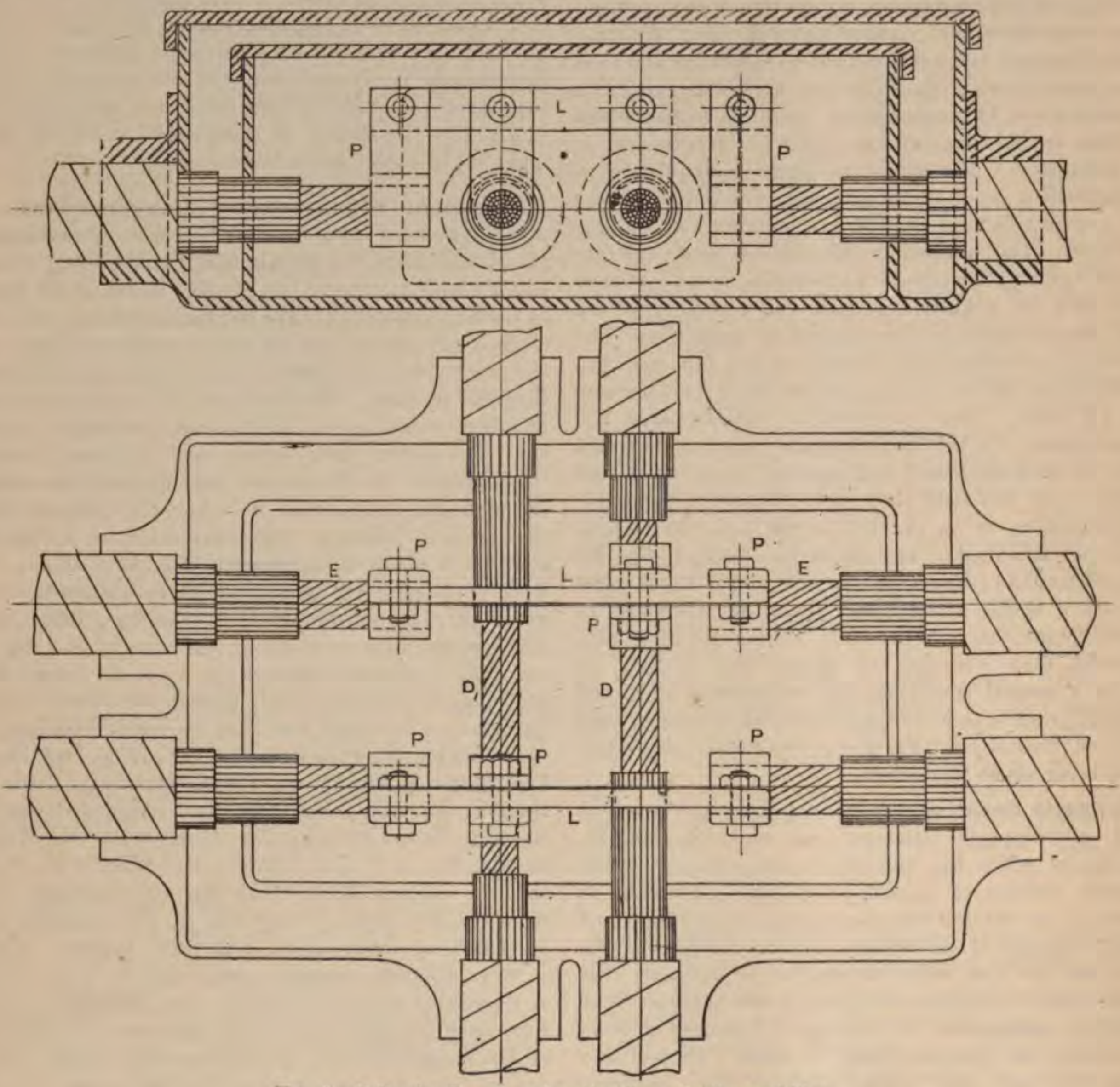

FIG. 5.—Callender Four-way Junction Box: Section and Plan.

We will first of all take the solid connection, premising, however, that it is now found desirable to use the second or changeable method in very many cases where the solidly insulated junction used to be employed.

In making the solid connection on the Callender system—as, for instance, where feeders are required to be permanently connected at a certain point to the distributors, or where two distributors are required to be connected in parallel to two other distributors at right angles—the method shown in detail in Fig. 5 is adopted. A double cast-iron box is prepared, cast in one piece, with an inner and an outer box, shown in plan and section, having their corresponding lids. This double box is pierced on all four sides with openings for the mains to be connected. The two larger mains are now cut to the requisite length to just pass a few inches into the inner box; and their copper ends, E E$_1$, are bared. A solid round copper socket, P, having a flat connecting piece projecting upwards, is securely sweated or soldered on each of these bared ends. The second pair of distributor cables, D D$_1$, are passed right through the junction-box without cutting, and a space of some inches is bared to the copper upon each of them—these spaces being not opposite to each other, but opposite to the mains to which they are to be connected. Similar copper pieces, P$_1$ P$_1$, are sweated to each of these bare places, one copper piece being fixed on the main D$_1$, on a line with the ends of the first main, E E, and the other piece being fixed on a line with the second main cable and projecting upwards to the same height as the copper pieces thereon.

All that has now to be done is to place solid lengths of copper bar, L L, across the mains, securely fastened by nuts and bolts—the positive main, E E, to the distributor D, passing over the other distributor within touching; and the negative to the negative distributor, D$_1$, passing over the positive without touching.

The cables and the connecting pieces are then insulated by semi-vulcanised material, and then protected by tape; the inner box is filled in with molten fine bitumen, and the cover placed on. The outer box is then similarly filled in with bitumen, thus forming a perfect protection from moisture getting into the joints in the inner box. The last lid is placed in its place, and the whole covered up with earth and finished off level to the road with the same paving as the roadway itself.

In certain cases these four-way boxes are left without the inner space being filled in with bitumen to allow junctions of house mains to be easily made. This type of box is, however, designed to be filled in solid and permanent, and, if accessible junction-boxes are required for the junction of house service mains or of a branch distributing main, a solid main fuse is used in a fuse-box with accessible manhole, as shown in Fig. 8 of our article on the Callender-Webber system on page 135, February 6. These accessible fuse-boxes are applicable to either system, solid or otherwise, and therefore need not be again described.

We now pass to the system of connecting mains and feeders in an ordinary central station network. In an extensive area of supply, the mains, both of feeders and distributors, will spread over a considerable area. Two things may happen to necessitate change in the connections. In the first place, a fault may be found, in which case tests would require to be made, and a certain length of cable might be required to be cut out of circuit; and, again, the demand for current may be altered in certain districts, and the points at which the feeders should feed into the distributors may require to be changed to some other point. It will be seen from this that a ready and rapid method of disconnecting mains, and of connecting up others in their place, is desirable on both grounds.

A simple yet ingenious method is used in the Callender system, shown in plan and section in Fig. 6, which illustrates a single-pole junction-box, having the ends of a network of four subsidiary mains connected to the feeding main. The principle of the arrangement is that of having, on the ends of each main, lugs of solid copper, which can be screwed to a copper "omnibus" bar, and so arranged that each, if unscrewed, can be swung round off the bar, and thus disconnected at once, without interfering with or touching any of the others.

The way in which this is carried out is easily seen in the illustration. A double cast-iron box similar to those already described for the simple four-way junction, has leading into it the ends of the main, M M_1. To each of these is sweated or soldered copper socket pieces, P, having a broad solid lug of copper, L, which is pierced for a bolt. The broad solid omnibus bar, O B, is bolted closely to these lugs, having a short piece of similar thick copper, S P, through which the full connection across is made. It can easily be seen that by unscrewing this swing-piece, S P, and swinging it back, the main, M_1, becomes disconnected.

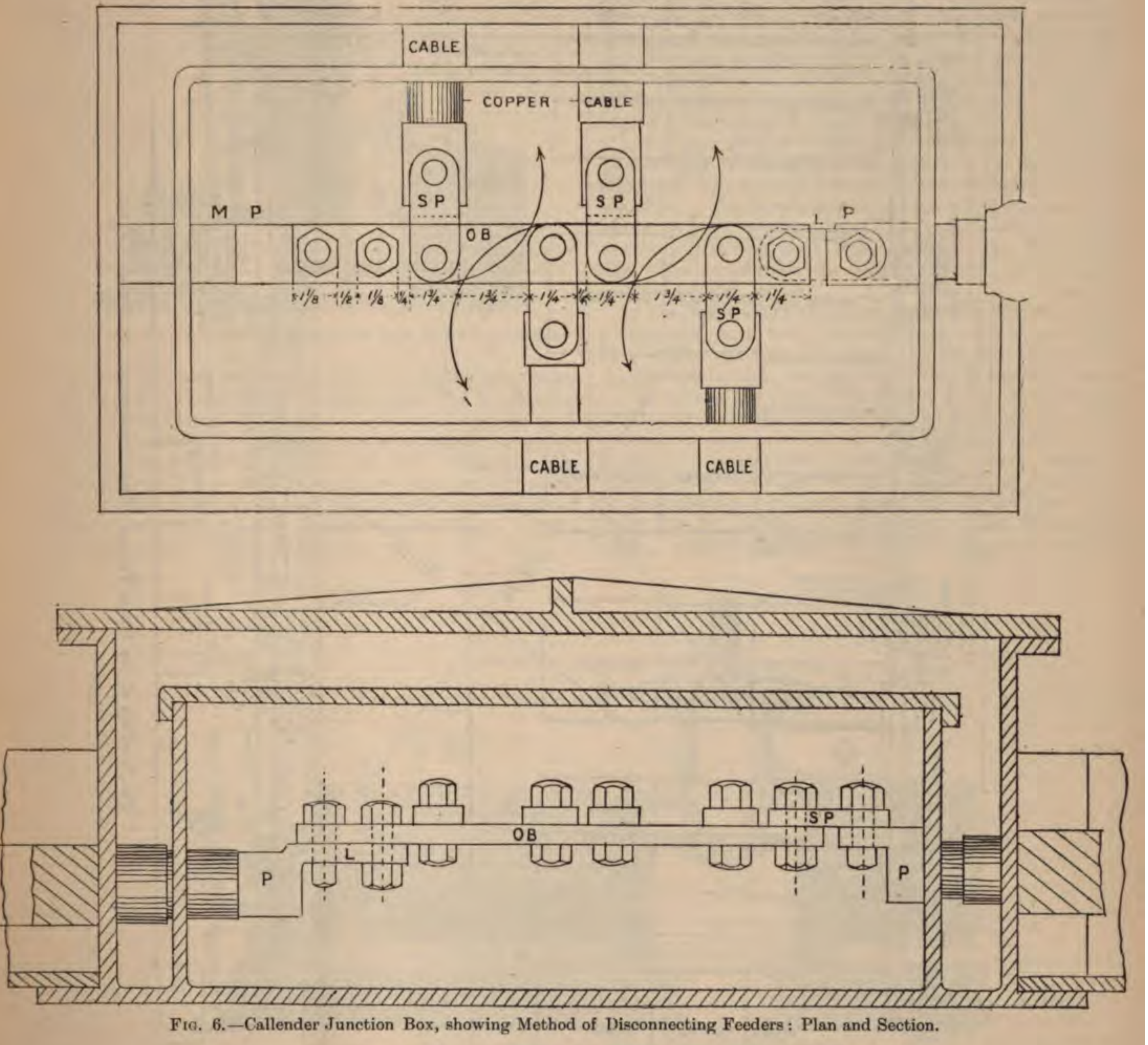

FIG. 6.—Callender Junction Box, showing Method of Disconnecting Feeders: Plan and Section.

In the same way the ends of the distributing mains are led into the junction-box, each having its end bared and a socket piece fastened thereto. Short swing-pieces, S P, are then bolted between the omnibus bar and these distributors. If occasion arises to alter the connection, or to cut off the supply from a certain district, all that is necessary to do is to unscrew one bolt and then move the swing-piece round clear of the bar The position of these pieces is arranged so that each can be swung round at its centre without the necessity for touching or removing any other connection.

(To be continued.)

THE POST OFFICE INSTALLATION.

(*Continued from page 158.*)

The Savings Bank branch of the General Post Office having been lighted by electric light for some considerable time with much success, and various country post offices having also received the benefit of this pure and cleanly light, it was only to be supposed that the General Post Office itself would be fitted in as perfect a manner as possible, so soon as arrangements could be made to instal the plant. Some time before Christmas last year the electric light was successfully started in the great sorting offices of St. Martin's-le-Grand, and both on account of the public nature of the institution, and also of the careful way in which the work has been carried out to guard against possible failure of light, the detailed description of the installation will be of interest to electrical engineers.

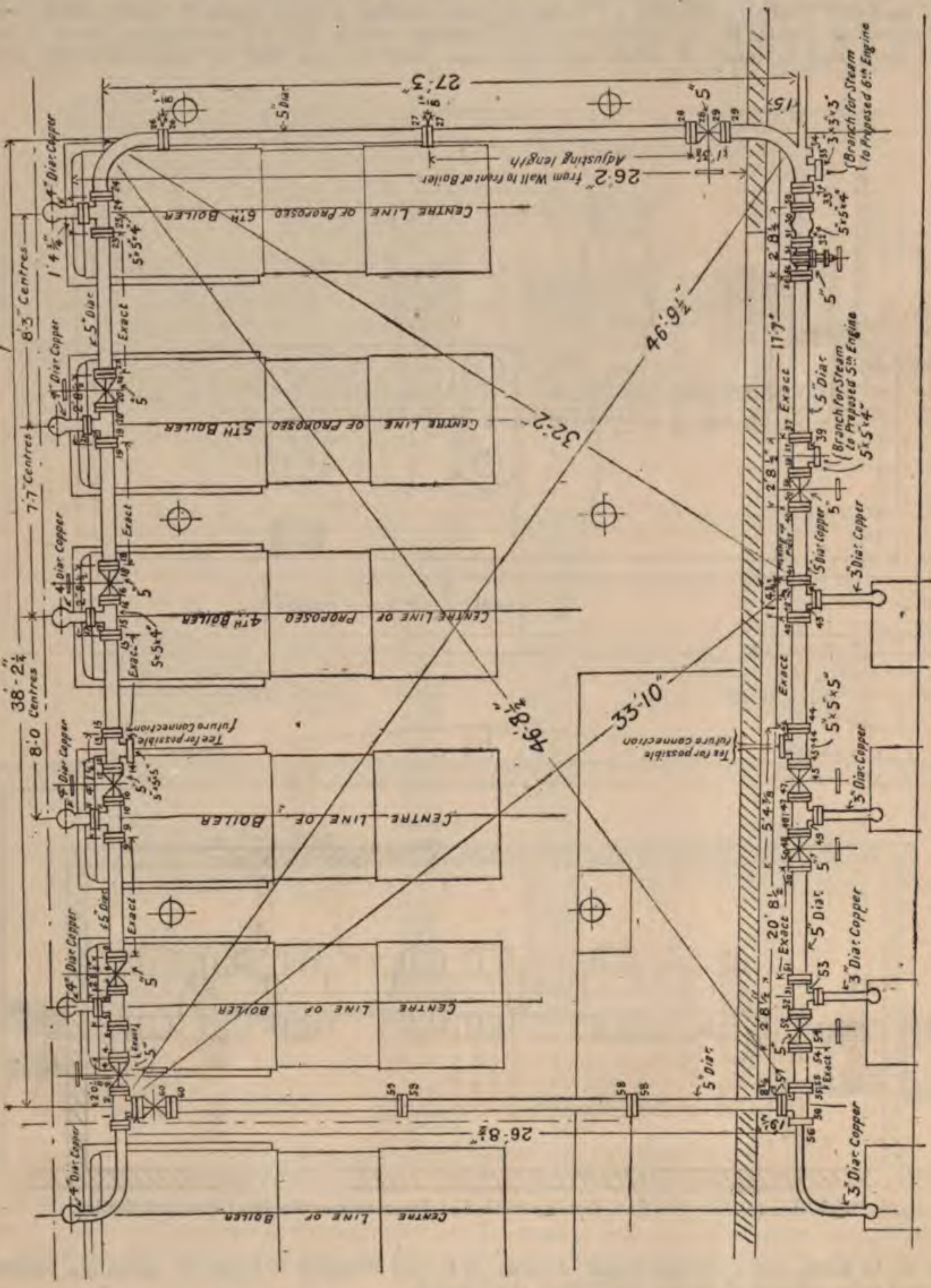
27' 5"
26' 2" from Wall to front of Boiler
Adjusting length
Centre Line of Proposed 6th Boiler
Centre Line of Proposed 5th Boiler
Centre Line of Proposed 4th Boiler
Centre Line of Boiler
Centre Line of Boiler
Centre Line of Boiler
8' 3" Centres
7' 7" Centres
8' 0" Centres
38' 2¼" Centres
46' 9½"
32' 2"
46' 8½"
33' 10"
26' 8½"
17' 7"
20' 8½"
5" Dia.
4" Dia. Copper
3" Dia. Copper
Exact
Tee for possible future connection
Branch for Steam to Proposed 6th Engine
Branch for Steam to Proposed 5th Engine

FIG. 9.—Plan of the Steam Piping. Ring Arrangement for Double Circuit.

The buildings known as the General Post Office, London, or more colloquially as St. Martin's-le-Grand, are, in reality, three separate buildings: two being at full work—the post office proper and the telegraph office—and one being in process of erection close to the others. They are known to the Post Office officials as G. P. O East, G. P. O. West, while the new building is to be the G. P. O. North. All these are to be lighted from one central station, whose position lies directly under the yard where the Post Office vans receive their sacks of letters to send throughout the country from the different railway stations. Some idea can be gained of the enormous industry of the Post Office when it is mentioned that an average of over 3,000,000 letters have to be examined, stamped, sorted, and packed up for delivery in a single day, and the long halls of this important central organisation of our busy metropolis contain thousands of sorting clerks busily occupied upon their work.

The installation comprises some 1,800 incandescent lamps of 16 c.p. and 60 Brockie-Pell arc lamps inside the buildings, with 16 Brockie-Pell arc lamps in the yard and outside. In addition, about 1,000 lamps are installed in the G. P. O. West, and more will be added during the course of the year.

We have given on the two previous weeks details of the switches and arrangements in the Post Office installation, and these will be referred to more fully in the course of the description.

The engine and dynamo room, as we have mentioned above, is in the cellars below the yard and a general view of this, showing the machinery, is given below. The plant consists at present of four sets of Willans and Robinson's G G high-speed engines coupled direct to Elwell-Parker 50-unit compound dynamos. The engines are of 80 i.h.p., and the dynamos supply current at 110 volts pressure. Two other engines of 200 i.h.p., coupled to similar 130-unit dynamos, will be added some time this year, and foundations are prepared for these additions.

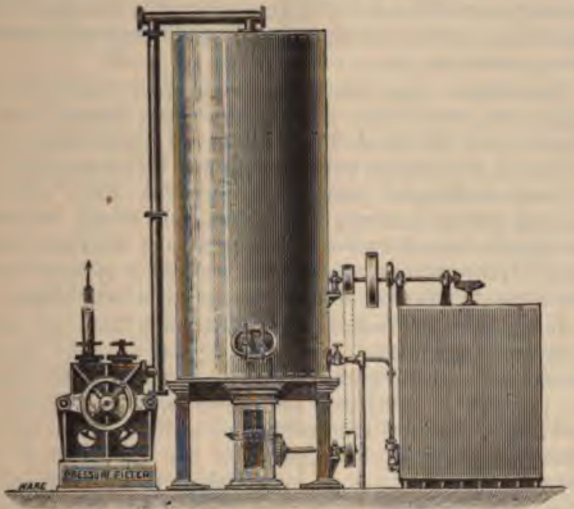

FIG. 10.—Porter-Clark Water Softener used at the Post Office

Each set is fitted with a Schaffer and Budenberg tachometer, and Dewrance and Co.'s patent sight-feed lubricators. The engines have all Willans and Robinson's latest improvements, amongst them being their steam separator, a chamber through which the steam passes, and into which the condensed water drains both from steam pipe and cylinders, thus providing dry steam, and also preventing possibility of rust when standing—rust in such engines being a more frequent cause of decay than wear.

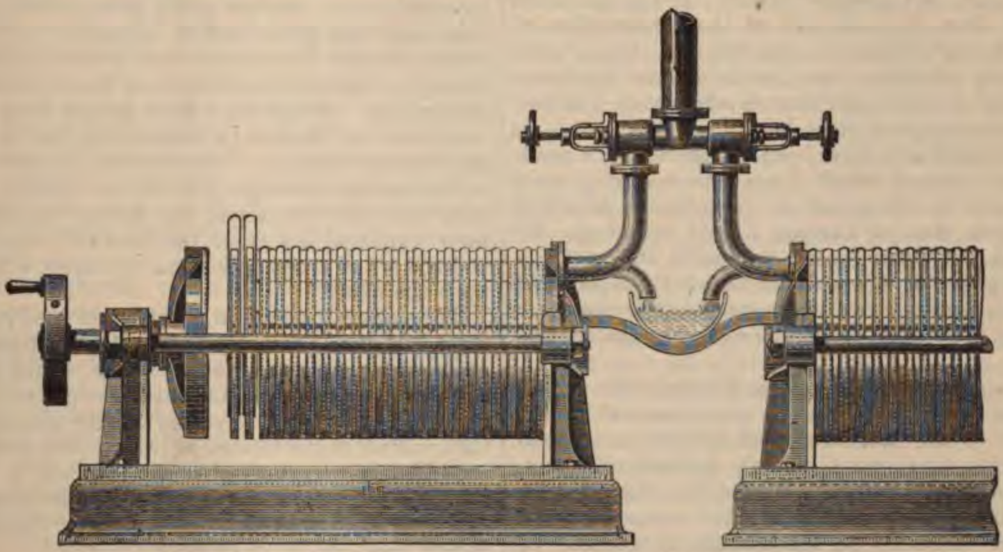

FIG. 11.—Pressure Filter of the Porter-Clark Water Softener.

The boiler-room is situated in a separate series of cellars close to the dynamo-room, and the arrangements have been very carefully thought out, both for security and facility of supply. In the first place, there is a complete ring circuit of steam piping, as shown in Fig. 9, giving a double path for the steam to any engine in case of accident to steam piping, and allowing any boiler or any engine to be cut off at will. The arrangement is made plain on the plan, which gives both the dimensions and the positions of all valves and connections. This scheme of steam piping makes quite a model system, and will be worthy of reference by those who are intending to put up similar important installations of electric plant.

The boilers are the Davey-Paxman locomotive multitubular type. There are three of these at present in use, and space is reserved for three others, making a battery of six in all when the whole Post Office plant is complete.

The question of incrustation in the boilers has received special attention, and a Porter-Clark water softener, made by Messrs. Porter Bros., 165, Queen Victoria-street, has been erected.

We are able to give a view of this water softener in Fig. 10, and a few words upon its action may be interesting. The incrustation which ensues from the use of hard water in boilers often—indeed, usually—becomes the thickness of ¼in., causing a waste of some 20 per cent. in fuel. If we assume that to evaporate 1,000 gallons of water per hour in clean boilers, one-eighth of its weight in good coal would suffice, we should have for 24 hours 108 tons ot water and 13½ tons of coal; and if with boilers encrusted with ¼in. of scale we lose 20 per cent., a very common case, only 86·4 tons of water would be evaporated instead of 108, and consequently 3·4 tons more of coal would be required. Taking, however, only two tons of coal extra, this, for 24,000 gallons per day, would result in a loss of 600 tons of coal a year, besides the deleterious results of hard firing. The remedy is to deprive the water of the minerals in solution before passing into the feed-water heater or into the boiler. The least costly reagent for this purpose in its action upon the bicarbonate of lime, usually found in hard waters, is lime used fresh from the kiln. The cost of this lime, allowing for all waste, does not exceed ¼d. per 1,000 gallons of water heated.

In the Porter-Clark apparatus we have in the first place a large cylindrical tank, into which the hard water is led by a supply pipe from the main. By the side of this is a smaller square tank, and the fresh lime is added to water in this tank in the proper proportion. The water supply sets in motion a small water motor, which in the first place pumps the lime mixture into the cylinder, and also, by means of a strap working vanes inside the tank, keeps the mixture well agitated. The water thus treated is forced, by the pressure of the main, along pipes to the filter. This filter, Fig. 11, consists of a number of iron frames and cloths, pressed together by means of a screw, and the water passing through these is run into a soft water tank, coming out beautifully clear and pure. From here it is taken as required to the feed-water heater and thence to the boilers. The sheets of the filter are unfastened and cleaned twice a week. Sufficient feed-water is kept in the reservoir to keep all four of the 80-h.p. engines going for five hours at full load. The feed-water tank has at present a three-way cock, to two of which are connected respectively a Worthington pump for filling the feed-water heater, and thence to the boiler, and an injector—thus giving double security of feed.

One difficulty that has had to be contended with is that the main drain of the street is 4ft. higher than the floor of the boiler-room. A large sump has therefore been built under the floor into which all waste water drains; from this it is lifted by an ejector to a large galvanised iron tank, fixed high up on the wall, and thence drains away into the main street drain.

(*To be continued.*)

NOTES ON THE ELECTRIC RAILWAY: HISTORICAL, STATISTICAL, AND TECHNICAL.*

BY FRANKLIN LEONARD POPE.

(Continued from page 169.)

It has been well said that "to rightly appreciate a discoverer we should not look at his work from our time; we should not judge of his work in the fulness of the light of present knowledge, but in the dim twilight which alone illuminated to him facts and laws then but imperfectly known. We must remember that at that date the steam engine was comparatively uneconomical, inefficient, and dangerous apparatus, and was regarded at best but a necessary evil; a thing to be tolerated and endured in the absence of available water power, but best dispensed with altogether wherever possible. At that date and for years afterward the annual catalogue of disasters by fire and explosion due to the use of steam was a lengthy and horrifying one. The report of a single year of the St. Louis Board of Trade gave a list of no less than 112 steamers which had been destroyed on the western rivers within the preceding 12 months by fire and explosion. Many people now living will remember the circumstance of over 60 persons being instantly killed by the bursting of a steam boiler in the heart of the business district of New York City. With such facts as these in mind it is easy to understand why the possibility of a new motor, compact, noiseless, manageable, free from all danger of fire and explosion, should be hailed with enthusiasm as a priceless boon to the industrial community. We must remember, too, that there existed at that time no data from which could be foreseen or determined, even with remote approximation, the relative economy of steam and galvanic power. It was not until 10 years later that the great law of the conservation of energy, and the correlation of the physical forces, now familiar to every schoolboy, was first formulated by Grove and Mayer and Joule; a law now so interwoven with our scientific conceptions that it is hardly possible for us to imagine that it could ever have been unknown. At a much later date than that of which I am now speaking, men whose names will be recognised as the foremost scientists of the time, such men as Lardner, Jacobi, and Joule did not hesitate to put upon record the belief that within a few years the power of steam would be wholly superseded by that of electromagnetism, and the *Scientific American* was publishing illustrated descriptions of perpetual-motion machines.

From the moment in which he first witnessed the experiment of lifting an anvil by Henry's electromagnet to the very last hour of his life, Davenport never once wavered in his belief that steam was ultimately destined to be supplanted by electromagnetism. Within six months from that time, with the assistance of another mechanic of the same town, he succeeded in constructing a machine by which he obtained continuous rotation by electromagnetic power. And it is worthy of remark that in this very first machine Davenport exhibited that unerring instinct of genius which ever distinguishes the true inventor, in that he grasped at once the fundamental conception of the combination of fixed and rotating electromagnets, the one reversible and the other non-reversible, which has characterised every commercially successful electric motor from the beginning until the present day. Time does not permit the rehearsal of the detailed story of his struggles, his failures, and his successes. During the six years between 1835 and 1841 he built more than 100 operative electric motors, scarcely any two of which were of the same design, and which varied in size from a small model up to an engine capable of driving a rotary printing press for 12 hours in succession. In December, 1835, he exhibited in Boston the model of an electric locomotive and circular railway which he had built in Springfield, and a similar, though more finely finished, model which was built by him the following year is still in existence in a good state of preservation. He published in 1840, now more than 50 years ago, in the city of New York, a weekly journal called the *Electro-Magnet and Mechanics' Intelligencer*, which was printed upon a press driven by an electromagnetic engine. Some of his motors, constructed as early as 1837 and 1838, were admirably designed, and in essentials, even to the shunt winding, differed but little from the present day.

Less than a year before his death, upon reading a newspaper account of the trial of the large engine built at Washington by Prof. Page under an appropriation from Congress, Davenport wrote a long and interesting letter to a local newspaper, congratulating Prof. Page upon his success, giving a concise but full account of his own work, and predicting with an earnestness born of entire conviction some of the most advanced and successful types in use at the ultimate triumph of electromagnetism over steam.

It has been the fashion to smile at such men as Davenport as enthusiasts. But may it not be that there is another side to the question? I do not forget that one of the greatest of American philosophers, Joseph Henry, has said: "The man of true genius never lives before his time. Though he may catch a glimpse of the coming light as it gilds the mountain top, long before it has reached the eyes of his contemporaries, and though he may hazard a prediction as to the future, he acts with the present." Viewed in this light, it may be said that Davenport did not live before his time. At least he acted with the present. It may be affirmed with entire truth that he gave every effort of his life to the development of his idea, and at last sunk into his grave, as he himself well realised, a victim of disappointed hopes. Yet, if Davenport was an enthusiast, so are we all enthusiasts as respects our anticipations of the realisation of the result which he predicted and for which he wrought unceasingly. Steam is nothing more than a convenient agency for the transmission of power, which derives its energy from heat and imparts it to mechanism. So soon as the great riddle of the day has been read—the production of electricity, as steam is produced, directly from heat—then, indeed, will the predicted triumph of electromagnetism over steam become an accomplished fact. Forty years have passed away since all that was mortal of Thomas Davenport was laid to rest beneath the Brandon elms, yet I think there are not many present in this audience to-night who do not cherish the expectation, if not the conviction, that before the half century has been completed the great problem will have been solved, and the era of a new industrial revolution will have dawned upon the world.

The electric locomotive constructed by Prof. George G. Page, which was tried by him on the Baltimore and Ohio Railroad in 1851, deserves a passing notice here. It was a noteworthy achievement, but developed no new principle, nor did it contribute anything to the ultimate solution of the problem of the electric railway. Many other promising experiments were made, but all resulted in failure, until the very name of electromagnetic motor became almost a synonym for "humbug." In discussing the question, Prof. Henry once said in his prophetic way:

"All attempts to substitute electricity or magnetism for coal power must be unsuccessful, since these powers tend to an equilibrium from which they can only be disturbed by the application of another power which is the equivalent of that which they can subsequently exhibit. They are, however, of great importance as intermediate agents in the application of the power of heat as derived from combustion. Science does not indicate in the slightest degree the possibility of the discovery of a new primary power comparable with that of combustion as exhibited in the burning of coal. We therefore do not hesitate to say that all declarations of the discovery of a new motive power which is to supersede the use of coal have their origin in ignorance or deception, and frequently in both."

I wish to call your particular attention to the remarks of

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* Paper read before the New York Electric Club, Jan. 22.

Henry in the paragraph just quoted, that electricity and magnetism are of great importance as intermediate agents in the application of the power of heat.

In these words Henry accurately foretold the true place of the electric motor in the domain of industry. Not a little confusion of thought exist at the present time in reference to this very point. Every day we hear somebody speak of electricity as if it were a primary motive power.

It only requires a moment's consideration to see that such a view is wholly without scientific basis. Electricity is not a source of power. What then, I hear the laymen ask, is electricity? Those of us who are most familiar with it have but one answer to that question. We do not know; and for my own part, I very much doubt if we ever shall know. This much, however, is certain, electricity is a very convenient and very manageable agency, perhaps a peculiar form of matter, perhaps a peculiar form of energy, by which any quantity of mechanical power may be instantly transferred from a prime motor, such as a steam engine or water-wheel, to a secondary motor at a distance, which is employed to do the required work. It really performs exactly the same office as a belt or a line of shafting in a factory, which, however useful in conveying mechanical power from one point to another can, under no conceivable circumstances, be capable of originating it.

The electric motor, therefore, remained, for something like 40 years after its invention, an interesting but practically useless philosophical toy. It was like half of a pair of scissors—of no earthly use without the other half. The other thing that was needed was an organised machine which could convert large quantities of mechanical power into electricity. The discovery that it was possible to effect this conversion was also due to Faraday. With his usual sagacity he had suspected that it might be done, and undertook a series of experiments for the express purpose of finding out. On the second day he wrote to a friend: "I think I have got hold of a good thing, but cannot say; it may be a weed instead of a fish which, after all my labour, I may pull up." On the tenth day he pulled it up, and it was a fish; it was not a small fish either. He had made a discovery which, without injustice, may fairly be compared to Newton's immortal discovery of gravitation. But Faraday was a man who possessed pre-eminently the scientific mind. His delight in the pursuit and detection of the great truths of nature was so intense and so absorbing that he was never able to turn from them for the purpose of following up their practical application. "I have rather been desirous," he once wrote, "of discovering new facts and new relations dependent on magneto-induction, than of exalting the force of those already obtained, being sure that the latter would find their full development hereafter."

This was the beginning of the development of the magneto-electric generator. The next step is due to the genius of another American scientist and inventor, one whose name will occupy a far more prominent position in the annals of American science a century hence than it does to-day, Moses G. Farmer. He it was who, in 1867, in a letter to Henry Wilde, of Manchester, England, first described the principle of the modern dynamo-electric machine, and explained to him why the principle of its action was not like that of "a man lifting himself over the fence by the straps of his boots," as he humorously expressed it.

Almost at the same time similar machines were independently invented by Wheatstone and Varley in England, and Dr. Siemens in Berlin. The invention of the dynamo-electric machine gave a wonderful impetus to the investigation of every branch of electric science. The subject was taken up by scores of enthusiastic workers in all parts of the world; improvement succeeded improvement, until we have as a result the exquisitely-organised dynamo-electric machine of to-day, a machine which is admitted to have reached a perfection and efficiency which leave but the narrowest margin for further improvement.

The earliest field of usefulness of the dynamo machine was found in electric arc lighting, which has become in the United States an immense industry. One of the most effective of the early machines was designed by Gramme, of Paris, in 1872, and a number of them were shown by him at an industrial exhibition at Vienna in the following year.

Here occurred one of those extraordinarily fortunate incidents, which again and again have played such a prominent part in the history of industrial progress. In making the electrical connections to one of these machines not yet belted to the engine shaft a careless workman attached to it by mistake a pair of wires which were already connected with another dynamo machine which was in rapid motion. To the utter amazement of this worthy artizan, the second machine instantly commenced to revolve with great rapidity in a reverse direction. When the attention of Gramme was called to this phenomenon, he saw at once that the second dynamo was performing the function of a motor, and that what was taking place was the actual transference of mechanical power through a small wire by the means of electricity. This singularly opportune occurrence being commented upon in the scientific journals, led to the almost instant recognition of the true place of the electric motor in the domain of mechanics. The late Prof. Maxwell, one of the master minds among electricians of the new era, expressed the opinion that the reversibility of the dynamo machine was the most important discovery of modern times.

(To be continued.)

ELECTRIC LIGHTING OF CARLOW.

Messrs. J. E. H. Gordon and Co., of 11, Pall-mall, are lighting the town of Carlow by electricity, the motive force being water power. The conditions under which this town was lighted may be of some interest, as showing what prompt work can be done by modern electrical engineering firms.

On a recent Friday Messrs. Gordon's representative in Ireland telegraphed that the Carlow Town Commissioners desired the electric light at once, and on the following Friday the town was illuminated by some dozen Brockie-Pell arc lamps and some 50 incandescents, and some of the principal shops were also wired and connected, the current being supplied by a Siemens dynamo erected in a mill in the centre of the town and driven by a water-wheel.

A long lease was taken of the Milford Mills, about 4½ miles from Carlow. A 45-unit alternating-current dynamo of the Elwell-Parker type, giving 2,500 volts E.M.F., was ordered, and arrangements were made to drive it from Milford Mills either by the water-wheel or a turbine which is being erected, and at times of heavy load by a combination of both. The current for the permanent lighting will be conveyed by overhead cables of the Fowler-Waring Company's make, insulated by the fluid insulators of Messrs. Johnson and Phillips. The transformers—of which, at present, there are eight 4 h.p. and four 2 h.p.—transform down to 50 volts. The low-tension current is conveyed direct to 12 arc lamps, and to a ring of low-tension mains supported on the same posts. At the centre of the town is a small distributing station for connecting the various circuits, and for disconnecting the long cable for testing purposes. There will be telephonic communication between the mill and this distributing station.

It is expected that the permanent lighting will be started at the end of March.

It may be of interest as showing how soon electric lighting becomes a necessity that on Messrs. Gordon proposing to take down the temporary plant, which they had erected for exhibition purposes only, the Town Commissioners stated that they could not do without it after once having had the benefit of the light, and arranged to pay rental for the temporary plant until the completion of the permanent plant.

Walsall.—Mr. Frederick Brown, of the Walsall Electrical Company, has been appointed to advise the Electric Lighting Committee of the Town Council on electric supply matters.

THE

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REFORM IN CONSULTING ENGINEERING.

Now that the Dublin authorities have come to a decision as to the acceptance of tenders for the electric lighting of that far-famed city, it will be as well to recall the history of the affair and to make a few comments upon the peculiar features of the transaction. By an order of the Council, dated Oct. 22, 1888, a committee was appointed to apply for a provisional order, to obtain estimates, and to enter into arrangements with contractors. A further order of the Council, dated Oct. 29, 1888, enlarged the area to be lighted. On the 3rd May, 1889, the license for public supply was granted, and on the 24th June last the license for private supply. Advertisements were issued in September and the tenders were in due course received. The borough engineer and the consulting electrical engineer considered and reported upon these tenders. This report has not hitherto been published in a complete form, so we give it elsewhere in order that references thereto may be verified. Our readers are fully acquainted with the fact that considerable delay arose in definitely settling which tender was to be accepted, and in the end a combination was accepted. The reasons for this policy may have been all-powerful and sufficiently adequate to convince the most sceptical observer, but to an outsider the information divulged is not reassuring. According to what may be gathered from the proceedings, the report of the engineers put aside all but three tenders, particularly recommending one, suggesting as better a combination of two or, best of all, a combination of three. The third tender in the end was somewhat harshly treated, as will be gleaned from our history. Our task is an exceedingly difficult one, in that we contend the whole system of tendering was a wrong one, and yet to condemn everyone for following their leader seems to be casting a stigma unnecessarily severe. In the first place, then, we contend that a consulting engineer should draw up plans and specifications to guide contractors, and not merely issue a few guiding clauses, leaving the contractors to make their own plans, their own drawings, and their own specifications. The contractors are not on the same footing, and in the result the brains of able engineers are sucked, to their great detriment, by men who are incapable of initiating comprehensive and complete schemes. Our remarks are perfectly general. Dublin is not the only case in point. There are but few men competent to make plans, and up to the present moment the aim of less able men has been to get the ear of the authorities, get the position of engineer, issue advertisements asking contractors to tender on their own plans, then select a scheme, or pick and choose parts of suggested schemes, accepting some one or other contractor to carry out the work, not as suggested by that contractor, but according to his plans with improvements suggested by other competitors. The taking of a suggestion from a nonsuccessful competitor in this fashion is a flagrant breach of confidence, and the sooner a systematic attempt is made by contractors to condemn it, the sooner will they be relieved from the intolerable burdens which now encumber them in sending in tenders. Another point we would notice is to be found in timid, ignorant, and incompetent advisers refusing to consider eligible any piece of apparatus that has not been tested by years of use. It seems incredible that the veriest tyro in electrical engineering should make a suggestion of the kind, yet it is one of the conditions attached to obtaining the work of lighting one of our most important towns. To hear the criticisms upon engines and upon boilers one would imagine the world to have revolved backwards through three centuries, for even in these directions so many years' warranty is required. But we have jumped from Dublin to another town, where, however, we consider the position worse than at Dublin, because of the pretensions of the adviser. The engineers at Dublin followed the rule, bad and condemnable as it is, and can only be said to have erred. The worst mistake made in the case was in suggesting the adoption of part of Mr. Gordon's scheme, and giving the work to another contractor. Messrs. J. E. H. Gordon and Co. sent in a complete scheme with elaborate drawings—a scheme which it is allowed would, if carried out, save from £800 to £1,200 a year in working. Of the system—suggested, be it recollected, only by these contractors—the engineers report: "We are of opinion you will do wisely in arranging to adopt this system. It will involve an extra expenditure on the basis of the lower tender of about £3,000; but, as pointed out by Messrs. Gordon and Co., the economy will be equal to nearly 25 per cent. of electricity sold." Again, the engineers say: "Sub-transformer stations, as recommended by some of the contractors and endorsed by us." If our information is correct, and, according to the documents before us, we cannot detect anything wrong in the conclusion, no other contractor than Messrs. Gordon tendered on the sub-station plan. Well, the question of acceptance of tender was to be considered, and after having seen the competing tenders and schemes, we find the following letter sent out:

"Engineers' Office, City Hall, Dublin, Dec., 1890.

"Dear Sir,—Please let me have, by 12 o'clock to-morrow (Tuesday) at latest, the extra amount to be added to your tender for sub-station transformer system (if used).

"There must be one line of cast-iron pipes for the H.T. primary wires, two lines of cast-iron pipes for three-wire distribution, and two lines of cast or wrought-iron pipes for arc light wires. There should be seven sub-stations, each with 10-4 H.P. electrical transformers, and each with a switchboard, enabling each pair of transformers to be connected as to the primary mains, and a three-way double-pole switch to each pair of transformers, the pair of transformers to be connected on to two or three wires of the distribution system.

"This addition to tender must include extra cost of cables, which must be to original specification as regards loss of energy. Please also state diameter of pipes.—Yours faithfully, "(Signed) SPENCER HARTY.

"W. G. Bingham, Esq.,
"House-to-House Electricity Co., Dublin."

No doubt the preparation of a tender is a simple matter in Ireland, at least so one would suspect, otherwise how could an engineer expect a revised tender, revised drawings, revised plans, etc., by "12 o'clock to-morrow." The position of affairs of course leaked out, and some pretty straight language was used by members of the Council. One gentleman is reported to have commented on this action in the following language:

"You will see in this letter that the House-to-House Company are asked to give tenders for a sub-station system at a few hours' notice. Now I assert that this is proof positive they were asked to copy Mr. Gordon's plans, for our engineers must have very well known that though it might have been possible to copy plans in a few hours, it would have been ridiculous to have asked any company to independently design that system in that time. I find that to work out the system in Mr. Gordon's office occupied the whole time of three skilled men for six weeks, and Mr. Gordon informed me that quite recently, having to design this system for another town, it took 16 days, even though the staff had the whole of the Dublin plan and calculations before them; this only refers to the details of the sub-station system, and not to the whole system. Before the dates of these letters the report was completed, and in that report we intended to recommend that the Electrical Engineering Company should be accepted, and that they should be allowed an extra sum of about £3,000 to adopt the sub-station system, and, in fact, we believed the labours of the committee were concluded, when we were suddenly called together again to reconsider our report. It then appeared that Mr. Gordon had heard of the proposed recommendation of the committee, and having remonstrated in writing without success, had come over from London and had called upon the chairman, Councillor Robinson, and had told him that he would be reluctantly compelled to apply for an injunction against us if we allowed his plans to be appropriated by others. A discussion ensued, and Mr. McSheehy was called in and asked whether we could legally adopt Mr. Manville's recommendation. The law agent replied that he could not give a legal opinion without further consideration, and his words were: 'It is a gross piece of piracy, and I won't help in it.' Notice of motion was then given by me to rescind the resolution, and, according to our rules, the meeting to consider my motion was adjourned for a few days. At the adjourned meeting Mr. Manville, who was sent for specially from London, was present.

"Now I will ask the members to kindly follow me when I tell them what occurred at that meeting, as I consider this a very important point.

"Mr. Manville at this meeting again informed us that, in spite of the opinion of our law agent, the Electrical Engineering Company could use the sub-station system, which he recommended, and Mr. Kennedy, the late Lord Mayor, and myself asked Mr. Manville a question, which we considered so important that we had previously put into writing; it was this: 'Have you in any of the tenders, except Mr. Gordon's, or in anywhere else in practice, seen or heard of the sub-station, practically or commercially, worked out?' to which Mr. Manville replied 'I have *not*.'

"Mr. Manville, finding that he could not persuade us to take the system, turned round, and then persuades us that there was nothing in it, and that it was not worth having. He told us then that the gross saving would not be more than £500 per year, which would be almost entirely swallowed up in the extra expense involved. In view of this statement of our engineer, we decided to save the capital cost of the sub-station system, and we recommended for acceptance the Electrical Engineering Company on the old system without sub-stations, which is the report you now have before you."

Consideration for our readers' patience prevent us pursuing this subject further at present. We have said enough to show that matters concerning specifications, plans, and tenders must come to a crisis. We have endeavoured to precipitate the crisis, and can go but one step further, which step we shall not hesitate to take, unless certain consulting engineers reform their methods of procedure. No consulting engineer has a legal or moral right to seek fishing plans, to put contractors to great expense, and then use the plans. He has no more right to give information to one contractor of the information supplied by another contractor, than he has to appropriate personal property to his own use. We were wrong perhaps in saying there was only one step more; there are two: (1) consideration of the question by the Institution, (2) the final—viz., legal proceedings. Lastly, we have used Dublin but to give point to our tale. The past is past; it is future trouble that may be prevented.

CANTOR LECTURES.

On Monday last Mr. Gisbert Kapp gave the first of three lectures in the theatre and under the auspices of the Society of Arts. A little consideration will show the great benefits conferred by the society in appropriating some of the Cantor lectures to electrical subjects, especially when it is remembered that Profs. Adams, Forbes, Lodge, and Thompson have in previous series dealt with special points concerning electrical engineering. And now Mr. Kapp is treating the subject of "Electrical Transmission of Power." This is an extremely interesting and at the same time an extremely difficult subject, especially when considered from the intensely practical standpoint of "cost," and this was the whole gist of Mr. Kapp's first lecture. We trust that Mr. Kapp, before he concludes his course, will make it perfectly clear that the data obtained from Mr. Fraser relative to the cost of running the Barking tramway is scarcely the right kind to be put forward for argument. The Barking tramway was, and to a certain extent is, an experimental line. Those who undertook it had something to learn from experience, and although it might have been necessary to depreciate the original type of accumulator used at the extraordinary high rate of 66 per cent., surely the improvements introduced will considerably affect this rate of depreciation. No doubt Mr. Kapp will tell us he was obliged to do his best with the meagre figures obtainable, and if he will only make this clear there will be no fault to find. We are told that experience has really gradually lessened the cost of running, so that now 8·068d. per car mile is considerably in excess of the actual cost. An examination of the figures given by Mr. Kapp shows that the depreciation of batteries alone came to 2·818d. per car mile.

Taking another point, we must congratulate Mr. Kapp for having dwelt upon a necessary proviso. The indiscriminate use of motors for power purposes, even when a central station is handy, will not pay the users, although it might pay the suppliers. From time to time we have insisted that the central station management will ultimately look to the supply of power first and light afterwards. Perhaps we have not fully explained our views when touching upon this question, but they are absolutely in accord with those put forward in Mr. Kapp's lecture. It is the intermittent user, the grocer who grinds coffee two hours a day, the butcher who chops meat for sausages a similar time, the jeweller and the watchmaker who want power occasionally, the dentist, the hundred and one other trades, not forgetting the printer who employs power at odd times and for comparatively short periods of time—these are the people who would benefit by, and who would benefit the central station. These are the people we want to convince that the electric motor is the cheapest apparatus they can employ when that motor is supplied with current from a central station. There is another class of people to whom power by a motor would be advantageous—those cramped for room, and to whom another machine, or another use for the space left vacant by the steam or gas engine, would mean increased profits far and away in excess of what they paid for power. In large towns, where special industries are aggregated about a common centre, want of space and cost of space is a far more important consideration than what is paid for power. Of course, these extraneous considerations cannot well come under review in what are more or less scientific lectures, but they will influence a great many users of power when electrical apparatus is better understood and becomes more common.

ELECTRICITY IN WARFARE.

On Tuesday last an interesting discussion was evoked by a paper read before the Aldershot Military Society by Major Hippisley, the subject being "Electricity, and its Tactical Value for Military Operations." As a matter of fact the discussion turned almost wholly on the application of electricity to lighting purposes. There seemed to be a general concensus of opinion that search-lights were most useful for a defending force, but not so useful for an attacking body; and General Sir Evelyn Wood stated that in one of the Egyptian campaigns he never went to sleep without turning the light on the enemy to see whether they were moving. The chief difficulty in employing a portable search-light appeared to the officers present on Tuesday to be the question of traction. To begin with, the pattern adopted in the English army was said by Major Hippisley to weigh seven and a half tons, against the four tons of a continental make. This is a very serious difference, which becomes the more apparent when it is further stated that an ordinary army team of horses is only supposed to draw one and three-quarter tons on a made road. And the less horses an expedition is burdened with the better. In fact, it does not seem to be a question, as Major Beresford pointed out, of whether the electric light is a useful adjunct to an army, but whether its utility is such as to counterbalance the cost and difficulty of transport. When considering this point, it must not be forgotten that the engine which drives the dynamo for supplying current to the search-light will also pump water and cut wood. Surely, however, our Royal Engineers can produce something lighter than seven and a half tons, if a foreign power, presumably France, for whom we believe Messrs. Sautter, Lemonnier, and Co. make this class of apparatus, can turn out an engine, dynamo, and wire-reel, mounted on a four-wheeled carriage, which weighs only four tons. Of course, it depends upon the length of wire carried, but even this weight should be capable of reduction.

RESTARTING OF THE DEPTFORD STATION.

The supply of current from Deptford station was recommenced on Monday. Since the fire the distributing station at the Grosvenor has been refitted with transformers, and the distribution is now effected by the current from Deptford at the full pressure of 10,000 volts transmitted along 16 miles of mains, no engines being now working at the Grosvenor. The load has been taken up gradually, 10 customers or so a day being put on, and many of the West-end circuits are now working. The supply is not yet put on continuously, but the service is from four in the afternoon to two in the morning. Before starting, trial runs were made by sending the current to Deptford and back for 24 hours continuously, and after one of these runs, and before putting on the customers, a trial was made running up the whole high-pressure part—dynamos and mains—to between 17,000 and 18,000 volts—going up from 15,000 to 17,000 within a quarter of an hour, the load being taken off in a water-tank resistance at Deptford. The supply has been on during the whole of this week and is again rapidly extending. The distribution of electric light is thus commenced on a practical scale from a distance comparable to the circumstances of a large gas works, and its progress henceforward will be watched with the keenest interest by electrical engineers and gas directors.

A GERMAN ELECTRIC LIGHTING AND POWER BILL.

The development which has taken place in the applications of electricity to lighting, power, and other purposes in Germany during the past few years, has induced the German Government to draft a measure to exercise a certain control over electric lighting stations, overhead and underground wires, installations, and factories where electrical apparatus is made. This Electric Lighting Bill has now been introduced in the Bundesrath. It comprises 15 paragraphs, of which the following are the principal regulations :

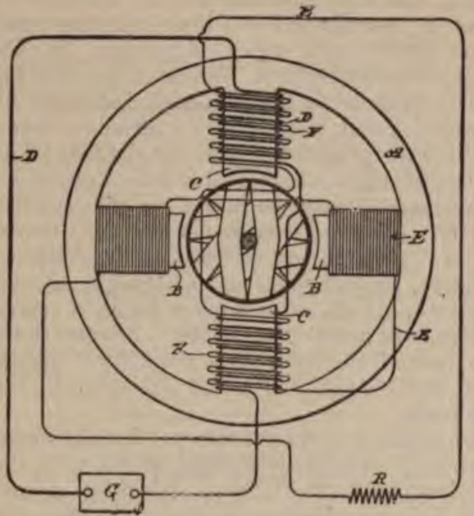
The erection and working of installations for the production, distribution, and application of the electric current for lighting, transmission of power, and other purposes, are to be controlled by the police regulations, which the Bundesrath will issue. Electric conductors or cables, intended to be carried along, over, or under public streets and ground, must be laid or put up in such a manner as not to interfere with existing electrical installations, or prevent the future use of the ground for the establishment of telegraphic, telephonic, or signal systems. The consent of the higher administrative authorities must be obtained before any installations, necessitating the breaking open or disturbance of public thoroughfares, can be put up. For installations established before the promulgation of this law, permission is not required, provided that the owners forward within six months a description of their existing installations, together with explanatory drawings, to the higher administrative authorities. Notices of intended installations must be forwarded to the Imperial Telegraph Administration, which is authorised within a period of four weeks to oppose the carrying out of the installation. The decision will depend upon the higher administrative authorities, but an appeal may be made to the country central authority (Landes-Centralbehorde). If, however, the Imperial Telegraph Administration is interested in the installation, the complaint or appeal must be made to the Bundesrath, which, after hearing from the country central authority, will decide the matter. Should the objections not be proved, the opponents must bear the costs. Permission must be obtained before alterations in installations can be made.

These regulations do not apply to installations erected on the property of railway administrations, or to those on the land belonging to the Imperial Telegraph Administration. Electrical installations in public exhibitions, etc., and in rooms or factories where explosives are manufactured, or where explosive gases may accumulate, must be examined by the local police authorities before being put into operation. Contravention of this regulation will be punished with a fine not exceeding £15, and the working of the installation may be suspended. The country central authorities are to determine which authorities are to be regarded as the higher administrative authorities. The Bill has been framed owing to the great extent to which electricity is now used for lighting and other technical purposes, and the Bill concerns generating stations, cables and conductors, installations, and electrotechnical works. The dangers connected with these installations consist in the possibility of accidents taking place owing to human beings coming into contact with electrical apparatus, the danger of fire, the possible interruption in the public telegraphic and telephonic services through short circuits or induction, and the breaking of thick, tightly-strained overhead conductors carried over streets and houses. In order to obviate these dangers, precautions must be taken that all electrical installations are carried out in the most efficient manner, so as to exclude the danger to life and loss by fire; the conductors must be erected so that no interruption will occur in the supply, and so that they will not break. A proposal was made that all electrical installations should be placed in the category of those trades included in the Trade Regulation Acts, but it was found impracticable. The present measure has therefore been elaborated for the purpose of controlling electrical installations, etc.

NEW TESLA ALTERNATING MOTOR.

We have already described a number of different forms of alternating-current motors designed by Mr. Nikola Tesla, depending upon a variety of phenomena met with in the employment of alternating currents. One general type of these consists of a machine with, say, four poles, between which is mounted an armature, generally wound with closed coils. On two opposite poles of the field are primary coils connected up in the main circuit. On the same cores are also wound secondary coils, which are closed through coils on the other pair of poles. When an alternating current is caused to pass through the primary coils, it energises directly one set of poles, and induces currents in the secondary coils, which in turn energise the other poles ; but the phases of the current in the secondary coils may differ in time from those of the primary current, and hence a shifting of the poles is effected that imparts a rotation to the motor.

In the new motor designed by Mr. Tesla, however, two energising circuits are brought into inductive relation in the motor itself, and the employment of an external induction device is thus avoided. The operation is dependent upon the existence of a certain difference of phase between the currents of the primary and secondary coils, and will be readily understood by reference to the accompanying diagram.



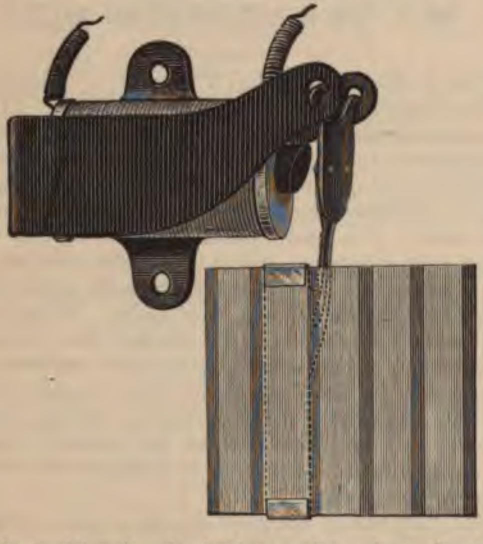
Here A represents the field magnet of a motor, which is built up of sections or plates. B and C are polar projections upon which the coils are wound. Upon one pair of these poles, as C, are wound the primary coils, D, which are directly connected to the circuit of an alternating-current generator. The secondary coils, F, are wound on the same poles with the primary, and connected with other coils, E, which surround the poles B.

The current in both the primary and secondary coils will lag behind the impressed E.M.F., but to secure the proper difference in phase between the primary and secondary currents themselves, the resistance of the circuit of the secondary is increased, so as to reduce as much as possible its self-induction. This is accomplished by making the coils E of comparatively small wire, having but few turns around the cores, or by inserting in the secondary circuit an artificial resistance, R.

In practice, it has been found desirable to wind the armature with closed coils, in which currents are induced by the action of the primaries.—*Electrical Engineer*, New York.

"NEW ERA" INDICATOR MOVEMENT.

A new and very simple pendulum movement for electric indicators is illustrated herewith. It consists of an iron frame, stamped out of one piece of metal, the two sides forming, at their extremities, bearings for the knife-edges of the pendulum, while between them is fixed the electromagnet. At the centre of the arm which, when the movement is in position in the indicator, is against the back of the case, are two eyelets, which afford the means of attachment to the same. It will thus be seen that as the whole movement only consists of two pieces—namely, the frame with magnet, and the pendulum—it is almost an impossibility for it to get out of order.

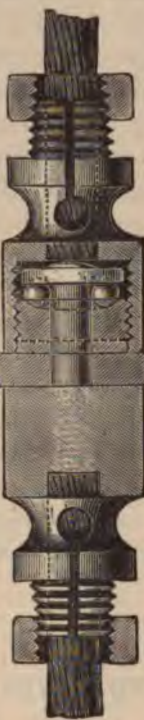


The method of working is as follows: Upon closing of circuit the magnet attracts the pendulum. When the circuit is again opened the pendulum is released, but as it is provided with knife-edge bearings, as pointed out above, it will swing backwards and forwards for a considerable time, thus attracting attention. The brass piece which carries the swinging indicator is carried up to prevent the magnet sticking.

The instrument requires no adjustment, and we think that the problem of a reliable, effective, and cheap indicator movement has been well solved by the production of the "New Era" movement, as it has been named by the International Electric Company (Mix and Genest), who are introducing it. The cost of such a simple piece of apparatus is naturally extremely low.

We may mention that the design has been registered under No. 162,129. It is an extremely clever and neat little piece of apparatus.

THE GWINNETT SWIVEL CONNECTOR.



A handy connector for securely and easily connecting up electric wires or cables is one of those little fittings often wanted and much desired by practical electrical engineers. Many patterns of screw connections have been brought out ere this, but a new one having some merits of simplicity and security is shown herewith, the patent of Mr. R. Gwinnett, of 7, Bath-street, Birmingham.

The union is made wholly of brass or gunmetal, and has a clamp at each end to hold the cable or wire. These clamps each consist of a lug, having a hole into which the end of the cable or wire can be pushed. Each lug is split, and has a taper screw-thread fitted with tightening nut, as shown in the figure. The electric conductor having been inserted, the clamp is tightened up by means of the nut to hold the conductor temporarily or permanently, as may be required. It will be seen that the conductors can thus be connected and disconnected with great ease and quickness, and great facility is thus afforded for setting out installations or effecting any alterations or repairs at a minimum expenditure of time and labour, and without the use of solder.

The union is fitted with a swivel of novel construction—an application of the well-known ball-bearing principle, allowing each half to turn round separately of the other. This allows for all twists, turns, or adjustments of the cables or wires, and takes out kinks without strain. This swivel is peculiarly suited for connecting the conductors for portable lights, etc., and the joint is so made as to be proof against dust and dirt. Quick connection and disconnection of conductors is assured, and the use of solder entirely done away with. For workshop and temporary use they will offer great convenience and saving of time. These swivel unions are made in running sizes, to suit the smallest wires and the largest cables, and their cost is very moderate.

Indian Telegraphs.—The new telegraph line from Calcutta to Bombay, *viâ* the Bengal-Nagpore Railway, will be opened for traffic at the end of February. The Telegraph Department will complete their new telephone exchange at Cawnpore this month. It is intended to open a similar exchange at Mandalay. Extensive repairs are to be carried out this year in two cables which link Ceylon with India. There are numerous faults which require to be repaired, particularly in the older cable, which was laid a quarter of a century ago.

ELECTRIC CRANES.*

BY REGINALD BOLTON.

The use of hoisting machinery is as widespread as trade, and as ancient as the Christian era, and forms a subject of interest to many engineers, while the question of its economies is of even deeper interest to all those engaged in the transport or movement of materials.

The application of electricity to this particular purpose is one that at first sight may not present great apparent advantage, but a consideration of the conditions to be fulfilled will, on the contrary, show that there is no more suitable conjunction of force and duty, and even at the present stage no purchaser of hoisting machinery can afford to disregard the claims of the conveyance of power by electricity, for reasons which the author hopes succinctly to show.

There are three considerations which present themselves, and which, if answered affirmatively, cover the whole subject.

Naturally, the primary one is (1) its comparative economy. The second in order is (2) its superior merits. The only remaining consideration being (3) its practicability.

Under the first we have to look into a few of the figures of electric and steam motors on cranes.

Now, an electric motor is in itself a most economical transmitter of power, its efficiency running as high as 90 per cent. in regular work, and if worked under proper conditions, its life may be as long as that of any ordinary steam engine, while under the special safeguards designed by the author its durability would be far more prolonged.

But the power must necessarily be generated and conveyed to this motor, and so the question of the economy of the generating dynamo and the power that drives it comes into question.

Such directly-connected engines and dynamos as are used on board ship, and in numerous central station installations on land, have repeatedly given a united efficiency of over 80 per cent. of the horse-power of the steam in the cylinder.

There are a far greater number of cases, however, where such a dynamo would receive its motion direct from a shaft driven by a larger engine, and in such a case an even superior result might be relied upon.

It would, in fact, be safe to assume an output of 85 per cent. of the actual power put on to the dynamo pulley, in the shape of electrical force, and as, in the case of shop cranes or wharf cranes, they would not be remotely situated from the generating dynamo, the loss in transmission would be small and can be stated at 1 per cent. to 2 per cent. only.

In the case of a large dock, with cranes situated at all parts, there would be greater distances to be dealt with, but even these would not exceed the limits of ordinary low-tension circuits, and the system would show a very favourable comparison in losses by transmission, as against the distribution of hydraulic power.

For all ordinary conditions, then, we may deal with the following figures :

1 h.p. put into dynamo results in............	·85 of 1 h.p.
Less by loss in transmission 2 per cent ..	·0085 ,,
Leaving the force put into motor as	·8415 of 1 h.p.
Output of motor 90 per cent............... =	·7573 ,,

Or a total loss of less than 25 per cent. Now take the comparative case of a steam-driven crane, say, of two tons power, having two cylinders each 5½in. diameter by 8in. stroke, running at 150 revolutions per minute. Such engines are on full work linked up to cut-off steam as late as ⅝ to ¾ of the stroke, and thus exhaust their steam at a considerable pressure. The usual boiler pressure is 70lb., maintained at an average of about 65lb., and wire-drawn by pipes and connections to, say, 60lb. initial pressure.

Under above conditions they indicate about 14½ h.p., but their consumption of steam is very considerable, and cannot be assumed at less than 35lb. per horse-power hour.

An excellent authority gave recently instances of such small high-speed engines absorbing over 40lb. per horse-power hour.

The net efficiency is still further reduced by the internal friction of the machines, which even in good engines would average 15 per cent., so that we arrive at a final efficiency of these engines used as motors on cranes of not more than 60 per cent.

On all small steam cranes, however, there is a further waste in the boilers, which, being small and of the vertical type, are far from economical in raising steam, and habitually consume 5lb. to 7lb. of fuel per horse-power per hour. In practice no crane is ever continually at work, and during the periods of lowering, changing gear, and stops, etc., the fuel continues to burn, and there is also the cost in fuel and labour of raising steam in the morning for the day's work.

It is customary among crane-builders to construct the boilers of steam cranes a good deal smaller than would be necessary if the engines were in constant running—the gain in pressure during the stops and changes mentioned compensating the loss of pressure during working, and the steam-gauge is consequently constantly on the move.

Now, against these figures we should have, in the case of a direct-driven dynamo, a better engine running with an earlier cut-off, and also necessary steam more economically raised. The motor when the crane is standing wastes no power, and the dynamo may be shut down or started at short notice. The crane driver need pay no attention to the crane when standing idle, and he starts without delay in the morning, the power being derived from the shop boilers.

There would thus appear to be a very decided economy in favour of the electric cranes, as against steam-driven machines.

In the case of overhead travellers, there is the saving due to the absence of long square shafts running in movable bearings, and which, together with the cotton or wire ropes in rope-driven cranes, are kept constantly running even when the crane is out of use.

ELECTRICITY IN WARFARE.

On Tuesday, Major Hippisley gave a lecture at Aldershot on the subject of "Electricity and its Tactical Value for Military Operations." The chair was taken by Field-Marshal Sir J. Lintorn Simmons, G.C.B., etc.

Major Hippisley pointed out the principal uses of the electric light in war, showing that they were of little use for the attack, but of enormous use in the defence. He maintained that the military were not yet fully alive to the importance of possessing portable search-lights for field operations, and drew attention to the fact that many foreign nations were far ahead of us. It behoved the War Office authorities to adopt some system of portable electric lighting, and he thought they could not do better than take pattern by their continental neighbours.

Lieut.-General Sir Evelyn Wood said : I want to indicate a point on which I should be glad if some of you will express your view. It has been said that no vote has ever been gained in the House of Commons by a speech. Now, I am on the opposite side to-day, though I am thoroughly convinced that no one could have put the case for the electric light more fully than the lecturer has done. I found the electric light of inestimable value at Kafr Dowar, and I never went to sleep at night without throwing the light in the direction of the enemy to see if he was moving ; and I had the same precaution taken several times during the night to make sure there was nobody moving outside the Egyptian lines. We did not know at the time how inert the enemy were. Is there a battle since 1859 in which the electric light could have been used by the aggressors. I do not say, Is there a battle in which the electric light was used by the aggressors, because that could be answered at once. It might be said it was not used because we are not sufficiently advanced. But has there been one battle fought within our memory in which the electric light could have been used by the attacking force with advantage? Perhaps some of you will tell us your view. I am possibly wrong. But I should like to know if you could ever get it up without being discovered in a night attack. The object of such an attack is, of course, a surprise. Now the noise of the engine alone would be heard long enough before you reached the enemy by a quick-eared scout. And then there is the unavoidable noise that would be caused by the pulling of horses. What is the weight of our engine?

Major Hippisley; Ours is 7½ tons; that one (indicating a diagram of an engine of continental pattern) is only four tons.

Lieut.-General Wood : Well I have asked Colonel Gratton, of the Army Service Corps, how much he expects a team to pull, and he says 1¾ tons on the level road. My experience of the engine is that we could not take it off the best macadamised road to get into the camp where we wanted it. It was practically impossible, and we had to leave it on the macadamised road, and never got it any further ; even if you got the weight down to 2½ tons you could not take it in and out of the camp unless you had a line of macadam. There is an officer present who will remember that we got nine battalions of men within 400 yards of a position we were going to assault, without being heard, and saw our friend strike a light to light a cigarette. It illustrates the importance of little things in a night attack. Now, if we do away with engine power we shall want more horses, and the General on the line of communication will object to every beast extra. He will fight against the artillery having more horses because it only adds to his difficulties as regards supply. I have taken intense interest in the lecture, but nobody will believe in it, unless they are placed in a position in which they mean fighting to the last man ; and I cannot find its utility for attack.

Major Beresford, R.E., said : There is one view of the electric light which I may be forgiven for mentioning. Major Hippisley, in advocating the cause of the electric light, forgot what in any branch of the service is always brought conspicuously forward—I mean moral effect. The artillery has its moral effect ; the cavalry has its moral effect ; and so has the new magazine rifle. So I think the electric light has its moral effect. Unseen dangers are always the worst, and I can easily imagine that a cheerful ray of light showing that there is no immediate danger ahead, would have its effect on the spirits of the men. I think the electric light would have a very good moral effect. The point to be decided, however, appears to be not so much, Will the electric light be useful on certain occasions? Everybody seems to admit that it will. What everybody wishes to know is whether the frequency of such occasions will be sufficient to warrant the expenditure for transport that will be necessary. It can be shown that the engines will not only be used for electric lighting but also for pumping water and cutting wood. I think since we have such a small army, and such a limited number of men, anything in any way that science can help us in we should take advantage of.

Colonel Lonsdale Hale said : I asked a question on one occasion as to whether the electric beam would penetrate Colonel Crease's smoke. Some people seem to think Colonel Crease's smoke a fad. Now, I have seen it tried at Portsmouth, and it is not a fad. At present the apparatus is somewhat cumbersome, and if Colonel

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* Paper read before the Civil and Mechanical Engineers' Society on Wednesday.

Crease can reduce it to portable proportions it will become a potent factor in the attack on a position. In the course of the experiments at Portsmouth, a body of men advanced within 200 yards of a position unseen under cover of the smoke. I bring this forward in connection with the electric light because it is important to consider. Sir Evelyn Wood took me to the other side of the Fox Hills when the electric light was being tried, and I thought if we have this smoke cloud, which can be made very portable, it will render the electric light comparatively useless in the field for search purposes. I think the smoke is one of the difficulties that Major Hippisley should have dealt with. With regard to another point mentioned by a previous speaker, there are very few battles carried on at night. If, instead of enquiring whether the electric light can be used for attacking purposes, we consider its uses on the battle field for the purpose of finding where the enemy is, I think we shall find that it may be uncommonly useful. After the battle of Coulmiers the defeated rested within a stone's throw of the men who had won the field. If the electric light had been there to search, the defeated enemy might have been pounced upon again, but in the absence of cavalry they did not know that the enemy lay at their feet. With regard to pushing forward the specialities of engineers, I think there will be little success in this direction until the department at Chatham is removed to Aldershot. Not the slightest progress can be expected with the useful specialities of the engineers until they are better established at Aldershot Camp. I am afraid the terrible diagrams Major Hippisley has placed before us are not much understood. We have tried our experiments at Chatham, and no good at all has resulted. We want our experiments tried here among the rough-and-tumble of Aldershot in contact with other troops. Only by these means shall we be able to make these things practicable. To the officer commanding the balloon section I should say; "I am not going to trust you as you stand at present. I will let you know every scheme I am going to carry out, and you shall do your level best to make use of your opportunities, and as you overcome your difficulties you will become more and more useful." It is only by bringing our specialties to light and working them out that you who are not engineers will believe in them; and if we have not the opportunity to do this at Aldershot, many useful inventions will remain pretty toys t Chatham.

Colonel Brine, R.E., said: What the last speaker has been laying down is being acted upon, and we are receiving most loyal support from Chatham. When we used the electric light last year the officer in charge was a distance from the light, and there was some little confusion, but that will not occur again.

The **Chairman** said: I have listened to this lecture with the greatest interest, but I think there are some points which require serious attention before the electric light is introduced into the service. I think there is great danger attending it because people will trust in it instead of trusting to the outposts. Tel-el-Kebir is often quoted as a night attack that might be copied. On that occasion there were no outposts whatever—I think not. The march on the night was undertaken under favourable circumstances. There were no hedges or ditches to get through; yet on the march the troops very nearly came to a disaster. I am told that the wings closed upon one another, while the centre did not march so rapidly, and the men came almost face to face. These night attacks are very dangerous and should not be adopted except under favourable circumstances, when the country is thoroughly well known, and the troops are well trained. Night attacks under other conditions will be attended with enormous risks, the troops, when they arrive at the position, will be unusually fatigued, and they will be alarmed by noises in the night, so they cannot be depended upon in the same way as in the daylight. Major Beresford speaks of the electric light as having great moral effect. I do not believe in the moral effect of the electric light if used for the purpose of attack. It might assist them in keeping their position, but I do not think it would otherwise assist them one atom on the march. It is very difficult to bring up three tons. As for four tons being drawn by four horses, you may as well try to move this hall with four horses. Four horses will not draw four tons over heavy ground, and on a newly-macadamised ground they would not move it at all. You need not be afraid of a locomotive. Although it could not pass over the bridges spoken of just now—the bridges near the Staff College—still it is capable of going over rough ground. Several years ago I saw eight or ten different kinds of locomotives tried at Birmingham. The course marked out was over a mile over hedges and ditches, and across ploughed fields. In the hedges an opening was made, a little wider than the engine, and the earth was thrown into the ditches. The locomotives were started and they went over the fields and the ditches, and it was quite an interesting steeplechase across country. Some of them stuck fast, I believe, and were never got out, but the majority of them got to the end of their journey and did remarkably well. You need not be afraid of the locomotive. It is best both for short and long distances; it is reliable, and does not get out of order as quickly as horses, and its "forage" is not so difficult to procure. There is another important consideration in connection with the electric light as a search-light. When used for coast defence you have a great expanse of level plain—water—and therefore the light can be thrown a very great distance without meeting with any obstacle. On land it is very seldom that you get such a favourable level, and it is seldom that you find a plain in which there are not holes sufficient to conceal large bodies of troops, and whom you could not see unless there was a man up in a balloon while the electric light is being used. I must ask you to accord a hearty vote of thanks to Major Hippisley for his valuable and interesting paper

REPORT OF THE ENGINEERS ON TENDERS FOR DUBLIN ELECTRIC LIGHTING.

APPENDIX A.

To the Chairman and Gentlemen of the Electric Lighting Committee.

Gentlemen,—We beg to submit herewith a detailed analysis of the various tenders received by your committee for the above. It has been a work that required a great deal of time and care in order to bring out the various points in the several tenders, and to put them in such a shape as will make the comparison easy to your committee and the members of the Corporation generally.

On the full consideration of these tenders and estimates, we find the prices estimated for the buildings vary so much, that we have eliminated this item altogether, in order to make a satisfactory comparison between the tenders. The design for the buildings will be a matter for future consideration, and in dealing with this portion of the work, we estimate that a sum not exceeding £4,000 will be required.

The bulk of the tenders for Specification B (boilers) provide for Babcock and Wilcox boilers, with the exception of Messrs. Crompton and Co., and Messrs. Gordon and Co. The description and tracings accompanying the various tenders for the Babcock and Wilcox boilers are identical in every respect, the prices only differing. The two firms above alluded to tender for Mills's patent boiler, which is much of the type of Babcock boiler, with the addition of a small water-jacketed furnace, and is said to give very excellent results. In the following analysis of the various tenders, therefore, no further mention will be made of boilers.—We are, Gentlemen, your obedient servants,

SPENCER HARTY.
EDWARD MANVILLE.

Analysis of Various Tenders Received for the Dublin Corporation Electricity Supply, 1890.

MESSRS. HORNSBY AND SONS.

Messrs. Hornsby and Sons' tender is moderate in price, and all the plant seems to be of good design, the electrical machinery particularly. The engines are substantial, but not quite of the most modern design. The electrical part of the machinery is altogether of Johnson and Phillips's manufacture, and as this latter firm's tender is identical with that of Messrs. Hornsby's, and exceeds Messrs. Hornsby's tender by £709, we do not propose to consider Messrs. Johnson and Phillips's tender. The alternators are of the Kapp type, the armatures revolving. This point is objectionable, it being the more usual practice to make the field magnets revolve, the armature carrying the high tension and dangerous current being stationary. The exciters also are coupled direct to the armature shaft, and in the event of these machines being adopted, it would be advisable to arrange with the makers to place a pulley on the end of the armature shaft to drive the exciter by ropes or belt, and thus prevent the possible breaking down of the small machine, incapacitating the alternator. The switchboards proposed by this firm seems to be well designed, and to meet the requirements of the case, with the exception that no mention is made of regulating apparatus, and there is no statement as to whether they would adopt automatic or hand regulation, or a combination of both. The transformers proposed to be supplied are, as far as can be judged from the drawing, of proper design—they are of the Kapp type. The meters tendered for by this firm are not described in any way, and it is therefore impossible to form any opinion as to their merits. It may be pointed out that the price for this item as tendered for by this firm is only half the price, with one exception, of all other tenders. This firm proposes two systems of main laying; the first consisting of Fowler-Waring concentric cables merely laid in a trench beneath the road surface, and otherwise unprotected. We are not aware that this system has been used anywhere in the United Kingdom for the conduction of high-tension currents. The same may be said of the second system proposed by them, in which a conductor roughly insulated with some hempen material is drawn into carefully jointed iron pipes, which are afterwards filled up with a heavy insulating oil, the pipe system being necessarily quite continuous. The second method would increase the price of their tender by £1,909, and it is important to note that their confidence in this system is such, that they would be prepared to guarantee the system of mains when laid by them for a period of five years. For the public lighting vertical semi high-speed engines, of their own manufacture, and of very suitable design, are proposed, driving Brush dynamos, supplying current to Brockie-Pell arc lamps on ornamental lampposts. The Brockie-Pell arc lamp is undoubtedly one of the best in the market, and the combination for this portion of the tender would be a highly desirable one. In connection with the exhaust-pipes it may be noted, that no mention is made whether it is proposed to carry the exhaust-pipe up through the flue, or to exhaust into the base of the flue, the latter plan not being at all desirable. Their price for the whole of the work, exclusive of the buildings, is £25,178.

MESSRS. SHARP AND KENT.

This firm's description is very incomplete. The engines are by Davey, Paxman and Co., and are likely to be of good design. The dynamos are not described, but, from the drawing attached, they appear to be of the type and manufacture of Goolden and Co., and the price tendered for by Messrs. Sharp and Kent is nearly twice that quoted by Messrs. Goolden and Co. for the same machines. The regulating apparatus and instruments are of Messrs. Sharp and Kent's design, but no particulars are given. Transformers, of the Goolden type. Meters, no particulars. Public lighting, no particulars. Price, without buildings, £33,580.

Messrs. Johnson and Phillips.

Messrs. Johnson and Phillips's tender is the same as Messrs. Hornsby's, except that the price is higher, and, therefore, need not be considered by us.

This firm proposes as an alternative to supply, under Specifica-A, Willans engines, coupled direct with Kapp alternators, without the intervention of belts or ropes, at a slightly increased price; and under Specification H, to replace Brush dynamos with arc lighting dynamos of their own construction, coupled also direct to Willans engines. This arrangement has the advantage of economising room considerably, and allows of a very perfect arrangement of steam-pipes, but we do not propose to recommend you to adopt high-speed machinery for this station.

Price, without buildings, £25,913.

Messrs. Edmundson and Co.

Messrs. Edmundson and Co.'s tender is identical in every respect but price with Messrs. Laing, Wharton, and Down's, and, therefore, is not considered here.

Price, exclusive of buildings, £34,267.

The Laing, Wharton, and Down Construction Syndicate Company.

The Laing, Wharton, and Down Construction Syndicate Company's tender is identical with Messrs. Edmundson's, excepting that their prices are lower. No particulars are given of the engines, except that they are of English make; the price for them is moderate. The only particulars given regarding alternators is that they are of the Thomson-Houston make, and there are no drawings. The transformers and meters are also of the Thomson-Houston type. The particulars of the mains and distribution systems are not given; this firm stating that they have included in their tender a price for a system similar to that in Newcastle. But they propose, if their tender is favourably considered, to place before you an entirely new method of electrical mains, which they believe will eclipse anything at present in use. In the public lighting they give no particulars of the engines to be used; but the dynamos and arc lamps are to be of the Thomson-Houston type. Their system of arc lighting is very well known and largely used. They state that the plant, with the exception of the engines, will be of American manufacture, and their price for the works, exclusive of buildings, is high—£32,240.

The Electrical Engineering Company of Ireland

Propose to supply compound engines, by Combe, Barbor, and Combe, of Belfast. It will be noticed that the size of these engines is considerably smaller than those of the same type provided for by the other contractors, the extra work being got out of the engines by running them at a considerably higher speed. In order, therefore, to make their price compare with that of other contractors, we have requested them to state the extra price for engines of a larger size, thus similar to other contractors. The reputation of the makers, Messrs. Combe, Barbor, and Combe is very high, and, though the general design of the engines is not so symmetrical as those of other more modern engine builders, their engines can be relied on as being of the highest class of workmanship and material. The alternating-current dynamos they propose to supply are those of the Brush Electrical Engineering Company's manufacture, of the Mordey-Victoria type. Their design is good, and they have attained a first-rate reputation. The switchboards, also of the Brush Company's make, thoroughly fulfil the conditions of the specification, and the combinations are neatly carried out. The instruments are of well-known types. Transformers also of the manufacture of the Brush Electrical Engineering Company's Mordey-Victoria type. The meters they propose to supply are Ferranti type, and they state, as an alternative, that they will supply meters of the Aron type. The system of conductors they propose is Callender's. This system is being largely used in London at the present moment, but we apprehend there would be an objection to the use of it in Dublin for the following reasons: The distance between the flagstones and the tops of the cellars in most of the streets through which the mains are to be laid is very small, and the Callender-Webber casings take up a good deal of room. This would involve the mains being laid generally under the roadways, and in that case the Callender casings, being but of weak structure, it would necessitate the laying of the mains some considerable depth beneath the road surface, thus very considerably increasing the expense of excavation and making good, which is to be done by the Corporation. In the event, therefore, of your proposing to accept this company's tender, they should be asked to reconsider the subject of main-laying, with the view of substituting cast-iron pipes and vulcanised rubber cables. The engines proposed for the public lighting are of good design, and are by Davey, Paxman, and Co. These engines drive Brush dynamos, regulated by Brush Giepel automatic current regulators. The company point out that the dynamos they quote for are each capable of supplying 55 arc lamps, if driven with a sufficiently large engine, and that their tender would be increased by the sum of £225 if engines of 60 brake horse-power were provided instead of engines of 30. This would enable one of the sets of plant to be kept spare, or it could be utilised to supply current to an extension of 50 more arc lamps, at this very small increase in price. The arc lamps proposed to be supplied by this company are of the Brush type. It may be well, if the company's tender is favourably considered by you, to suggest the substitution of Brockie-Pell lamps in place of the Brush lamps, the lamps being about the same in price, and the results given by the Brockie-Pell lamps being probably superior to those obtained from the Brush lamp. The lamppost as proposed to be supplied by them are of ornamental and suitable design. The company suggest as an alternative Specification A, the substitution of four engines of the Brush Company's make, running at a semi-high speed and driving four dynamos of a smaller size than those specified for, and supplying two exciters instead of four, not coupled to or driven from the dynamo shaft, but coupled direct to two of the Brush Company's engines. As before stated, we do not propose to advise you to adopt semi high-speed engines for the private lighting, and, in addition, the use of these engines would increase the price of their tender. The Electrical Engineering Company of Ireland point out that they are an Irish company, and that almost the whole of their capital has been raised in Dublin, that it would be their object, if the contract is allotted to them, to place as much of the work as possible in the hands of Irish manufacturers. Total price of their tender, exclusive of buildings, is £26,007.

Since the above was written, this company has sent in, at our request, price and tracing of engines of Messrs. Combe, Barbor, and Combe's make, of about the same ratio of work to size as those quoted for by most of the other contractors, and also tracing of an engine of about the same size by Messrs. Victor, Coates, and Co., and the price of their tender for either of these engines is increased to £5,658. Undoubtedly the workmanship and material on engines of both these makers is excellent, but, as stated before, the general design of the engines is not symmetrical and as massive as some of those quoted for by other makers. The Electrical Engineering Company of Ireland point out that engines of both these makers are built in Belfast. They also now quote for Messrs. Fowler's engines, their price for these being £7,308, and these engines are criticised under the Irish House-to-House and Messrs. Ryan and Purcell's tenders. Taking Fowler's engines as now quoted for, the estimate of this company amounts to £28,907, without buildings.

The Irish House-to-House Electricity Company

Have prepared a very complete tender, and the plant they propose to supply would seem to be of the highest character throughout. They attach a detailed tracing of the engines they propose to supply, but do not give the maker's name. From, however, this tracing, and the dimensions given, and the similarity existing between these and the particulars given by another contractor, it is fair to assume the engines are by Messrs. Fowler and Co., of Leeds. The price attached to Specification A for these engines is, however, exceedingly high, being no less than 50 per cent. above the price of the other contractors tendering for the same type engine. These engines have been very successfully used by the House-to-House Company for central station lighting, notably at Kensington and Madrid, besides, we believe, at some of the smaller stations, such as Hastings, Eastbourne, etc. The dynamos are of the Lowrie-Hall type, with stationary armatures and revolving field magnets. These machines are of the same type as those quoted for by two other contractors, and again the price is in both cases higher than the other contractors. These machines have been used in the same central stations as referred to above in connection with the engines. The exciters are uncoupled and driven by ropes off the alternator shaft. The regulating apparatus is automatic, and of the Lowrie-Hall type, and, in addition, hand regulation is provided. The alternating switchboard is very well designed, and also of the type used in the stations above referred to. The instruments are by Sir William Thomson and Cardew, and Messrs. Elliott Brothers. The transformers are also of the Lowrie-Hall type, ard of good design, being the same as used at Kensington, Brighton, Eastbourne, Madrid, etc. This firm gives a choice of meters, either the Ferranti, Shallenberger, or Lowrie-Hall. The system of mains they propose to supply is the same as that adopted by them in the stations above referred to, and consisting essentially of cast-iron pipes, 3in., 4in., and 6in. in diameter, arranged with surface boxes for drawing in and out cables, and junction boxes placed under the road surface opposite the party wall of houses, to enable the houses to be connected up. Into these cast-iron pipes are drawn cables insulated very highly with vulcanised indiarubber. No particulars are given as to the maker of the semi high-speed engines proposed to be used for the public lighting, but from the drawing and specification attached they appear to be of good design, and they are fitted with everything required to make them perfect in detail. The three continuous current generators are fitted with special automatic current-regulating apparatus, and supply current to Brockie-Pell lamps placed on lampposts of plain design. The company states that 25 per cent. reduction could be made in their estimate all round, if plant of a less costly kind be provided. They also suggest that the transformers, instead of being placed in metal cases as specified, should be placed in a brick chamber protected by an iron door, with lock and key, and also suggest that the double-pole switches should not be used at all at the transformers. They state that they are not limited to the use of the arc light plant included in their tender, and are prepared to supply in place of it, if required, any system at present in the market. It may be well to point out that this company, together with one other contractor, are the only ones who have furnished detailed specifications of each part of the plant proposed to be used. Their total price for all the plant, delivered and erected, excluive of buildings, is £31,398.

Messrs. Woodhouse and Rawson United, Limited,

Propose to supply engines of their own make. The design of these engines is rather antiquated, and it will be noticed that they have to produce a higher ratio of work compared to their size than any of the other engines specified by the remaining contractors. The alternator which they propose to use is of a type comparatively novel. It is called the Kingdon type of alternating dynamos, and its advantage is that the moving parts carry no current whatever. So far as we are aware the only town central station in which this type of machine is used is Woking, where they have been just started, or are just about to be started. Exciters uncoupled. The switch appliance is to be of their own manufacture, likewise the instruments, but the tender is quite unaccompanied with details of the apparatus, and they specifically state that they have not included the synchronising apparatus. The transformers they propose to use are of the Brush type. The mains are of the same type as proposed by several other contractors—*i.e.*, cast-iron pipes and vulcanised rubber cables—but the amount of their tender for this is astonishingly high. The engines for public lighting are of their own manufacture, and are to supply Brush dynamos giving current to Brockie-Pell arc lamps, and they have only included two sets of engines and dynamos for public lighting, large enough to do the work between them, instead of three as specified.

Their price, exclusive of buildings, is £32,043.

MESSRS. CROMPTON AND CO.

In addition to sending in a tender for plant according to specification, send in an alternative tender for plant on the three-wire low-tension system, which we have considered further on in this report. The engines they propose to supply are made by Messrs. Pollitt and Wigzell, 17½in. high-pressure cylinder, 28½in. low-pressure, with stroke of 42in. They do not enclose drawings of the engine, but it will be seen that the dimensions are larger than those specified by all other contractors, with one exception, and the reputation of the makers is a guarantee for a first-class article. The boilers they propose to supply are, unlike those tendered for by most of the other contractors, not of the Babcock and Wilcox make, but of what are known as the Excelsior, or Mills patent type. These boilers very much resemble, in their general arrangement, the Babcock and Wilcox boilers, with the addition of a small water-jacketed furnace. We notice that these boilers proposed by Messrs. Crompton and Co. are smaller in size than the Babcock and Wilcox boilers, proposed by other contractors. Thus, the total heating surface in the Babcock and Wilcox boilers is 2,531 square feet, and in the Mills boiler 2,126 square feet. In the Babcock and Wilcox boiler the total grate surface is 51 square feet, and in the Mills boiler 49 square feet, and the dimensions of tubes, and the various other portions of the boiler, are uniformly smaller throughout than the Babcock and Wilcox boiler. These boilers are said to have shown very high evaporative duty on recent test. The alternators proposed to be supplied by Messrs. Crompton and Co. are of the Kapp type, made by Goolden and Co., the exciters being of Crompton's own make and coupled. The regulating apparatus proposed to be supplied by them is not automatic. The switchboards, which are of their own make, are well arranged, but no mention is made of the makers of the various instruments proposed to be supplied, and therefore no idea of their value can be formed. The transformers Messrs. Crompton and Co. propose to supply are of the Statter type, arranged in perfectly water-tight iron casings, and are suitable for placing in the open air if necessary. The meters proposed by them are of the Aron type; the mains they propose to supply are vulcanised rubber highly-insulated cables. These cables they propose to lay in shallow conduits constructed under the surface footways in cement concrete.

This culvert would be divided into two sections by a brick partition, the positive wires being laid on one side, the negative wires on the other. We would point out here that the Corporation would be put to a considerably greater expense in excavation and making good by adopting this plan, and that also it would probably be unsuitable without considerable structural alterations for a considerable portion of the length of the mains, where they will have to be of necessity laid under the roadways instead of the footways.

Messrs. Crompton and Co. state that they only intend in this tender to lay a double line of culverts, one under each footwalk in O'Connel-street, and they do not enclose any map showing the run of the mains. For the public lighting plant they propose to supply engines of Davey, Paxman, and Co.'s make, but give no particulars. These engines would drive continuous-current generators, fitted either with their own constant-current regulator, or with the Statter constant-current regulator. The arc lamps are of their own make, and have earned a reputation for steady burning. The lampposts suggested by them are of handsome appearance. Messrs. Crompton and Co. state that the efficiency of the system might be much improved by the use of transformer substations in lieu of placing a separate transformer in the house of each consumer. We refer to this subject again later in this report.

Price, exclusive of buildings, is £27,154.

THE ELECTRICAL CONSTRUCTION CORPORATION.

The Electrical Construction Corporation's tender for engines gives no particulars, and therefore it is impossible to form any opinion of their relative value. Their price, however, is highest of all but one. Their boilers are Babcock and Wilcox. The alternators are of their own make, and perhaps have been used in larger numbers in the United Kingdom than those of any other maker. Their price for these machines is lower than the prices of the two other contractors who tender for machines made by this company. The regulating apparatus is only hand, and not hand and automatic combined. The switchboard is well designed, and the instruments by Sir William Thomson, Elliott, and Cardew. The transformers also are of their own manufacture.

The amount of their tender for Specifications A, B, C, D, and E is £20,831.

MESSRS. RYAN AND PURCELL

Propose to supply engines of Messrs. Fowler and Company's manufacture. These engines are practically identical with those proposed to be supplied by the Irish House-to-House Company, and it will be noticed the price is 50 per cent. lower. The boilers, by Babcock and Wilcox, are also quoted for at a price much lower than any of the other contractors. The alternator current dynamos of Statter type, with coupled exciter. These dynamos have not been used for central station lighting in the United Kingdom. In the event of this tender being accepted, we should advise that the contractors be directed to drive their exciters by ropes instead of having them directly coupled. The switchboards are of the same type as quoted for by the House-to-House Company, and are very complete. There is an especially ingenious device for both the automatic and hand regulation, which is to be worked by pressure obtained from the Corporation water mains. Switchboards are also well designed for extensions. The instruments are by Sir William Thomson, Cardew, and Elliott Bros. Transformers of the Statter type are stated by this firm to be the same as those supplied to Messrs. Crompton and Co. for the lighting of the town of Chelmsford, and to the same firm for the lighting at the Barry Docks. They propose to supply meters of the Ferranti type. The system of mains they propose to use consists of cast-iron pipes, 4in. in diameter, with cables highly insulated with vulcanised rubber. They state that two lines of pipes will be laid in most streets, and one line of pipes in others, probably the narrow streets. In the event of this tender being accepted, it would be better for the contractors to give an extra price for the laying of double lines in all streets. For the public lighting, vertical tandem compound engines, of the Allen or Gwynne, or similar type, are proposed running at 220 revolutions per minute, and driving generators of Statter type, with patent constant-current regulation. These generators supply current to Statter arc lamps, mounted in lanterns instead of globes, in very ornamental posts. In the event of this tender being accepted, we think that Brockie-Pell lamps should be substituted by the contractor for the one proposed. This firm do not include in their tender the price of lampposts, and a few extras in the public lighting, amounting in all to £1,024, and the price for the whole of the work, without buildings, inclusive of the £1,024, is £24,472.

MESSRS. J. E. H. GORDON AND CO.

Messrs. J. E. H. Gordon and Company's tender is perhaps the most complete one sent in, going, as it does, specifically into the smallest details of the plant proposed to be supplied by them. The engines they propose are by Robey and Co., fitted with Richardson's automatic trip expansion gear. The high-pressure cylinder, 17in. in diameter; the low-pressure cylinder, 30in. in diameter; stroke, 40in.; and speed, 75 revolutions. The engines are evidently of very excellent design, and large for the work they have to do. The boilers proposed by this firm are of the Mills type, previously referred to in this report under Messrs. Crompton and Co.'s tender. It is pointed out by Messrs. Gordon and Co. that the following efficiencies will be guaranteed by them for these boilers: When burning Lancashire engine coal, 9lb. to 9½lb. of water will be evaporated per pound of coal; when burning good Newcastle coal, 10lb. of water will be evaporated per pound of coal; and when burning good Welsh coal, 10½lb. of water will be evaporated per pound of coal. These efficiencies are exceedingly high. The whole arrangement of the engine-room, as proposed by them, is very well planned, there being a duplicate system of steam-pipes so arranged that any joint breaking will not shut off steam for more than one engine. The steam-pipes are to be of wrought iron or mild steel, with copper connection pipes, arranged to allow for expansion and contraction without the introduction of special expansion joints. The main exhaust-pipe also is carried right up to the top of the chimney, steadied by wrought-iron hoops. Considering the high class of the engines proposed to be supplied, and the excellent arrangement of steam and exhaust pipes, the price for the engines, £7,605, is not a high one. The dynamos they propose to supply are either of the Lowrie-Hall type, running at the rate of 350 revolutions per minute, with exciters driven by ropes, or of the Siemens type. Their price for the dynamos is £3,771, as against £3,675 for the Electric Construction Corporation. The regulating apparatus proposed to be supplied by them is of the type used by the Metropolitan Electric Light Company in their Manchester-square station. It is complete in its way, but does not provide for the combinations specified; notably, no mention is made of synchronisers, although, from the reading of another portion of their tender, it would be inferred the dynamos are intended to run in parallel. The instruments by Goolden and Co. For transformers the maker's name is not mentioned, but the price included for numbers specified is £2,534, or less than that of any other contractor.

Messrs. Gordon and Co. point out, as also does one other contractor, that they recommend sub-transformer stations, instead of placing separate transformers in each house to be supplied; and this subject is considered by us further on in the report. They propose to supply meters of the Westinghouse or Shallenberger pattern, and their price for these is lower than that quoted by other contractors for the same meter. The system of underground mains proposed to be supplied by this firm, according to specification, consists generally of three lines of pipes laid on one side of the street, and two lines of pipes laid on the other. These pipes to be of earthenware, with patent Archer joints, completely surrounded by Portland cement concrete, and provided with manholes, junctions, boxes, etc. The arc light wires to be drawn into one pipe on each side of the road. The second pipe on each side of the road to be used for the distributing wire, from which the connections to consumers' houses are made; and the third pipe on one side of the road to be used for containing the feeding mains which are joined up at long intervals to the distributing wire on both sides of the street. The advantage of using a separate duct for the feeding wires, as pointed out by these contractors, is that when fresh cables have to be drawn in for extension, no interference will occur to the connections to consumers' premises, as might occur if the feeding wire were drawn into the same duct as the distributing wires, and, in fact, however much the system may be extended, no fresh wires are drawn into the duct containing the distributing wire. The public lighting which these contractors propose to supply includes two semi high-speed Robey engines, running 220 revolutions per minute, provided with an electrical governor, and driving two 55-light Brush machines, supplying current to Brockie-Pell arc lamps, or, as an alternative, Thomson-Houston dynamos supplying current to Thomson-Houston arc lamps, on ornamental lampposts. They also suggest a more expensive lamppost with raising and lowering gear, but involving complications, the adoption of which we cannot see our way to recommend.

The amount of this company's tender for the entire work, buildings excepted, is £33,409.

The Babcock and Wilcox Company

Quote for their own boilers, and for feed-water heaters, which are included in the specification under Specification A. The total amount of their tender is £5,003, which, deducting the amount for the feed-water heaters, quoted at £678, and allowing £22 for carriage and fixing, makes their tender for the boilers alone, say, £4,300.

Messrs. W. T. Goolden and Co.

Tender for alternators, instruments, and transformers. The alternators are of their own make, and of the Kapp type ; the armature revolves, and the same objections apply to it as set forth in the portion of the report referring to Messrs. Johnson and Phillips's tender.

They send no tracing of the switchboards, which are of their own make, and they provide combined hand and automatic regulation gear. The instruments are of their own make, and Cardew. The transformers are of the Goolden pattern, with closed magnetic circuits.

Messrs. Siemens Brothers and Co.

Tender for alternators of their own construction. The drawing does not clearly show whether the armature or field magnets revolve, but we believe the armature revolves, as in the Kapp type machines. The exciters are Siemens continuous-current machines, and are driven by ropes off the alternating shafts. The tender for the alternators, £2,540, is the cheapest on the list. Of the switchboard and instruments, the switchboard arrangement is neatly designed and efficient, but only hand regulation is included. The instruments are not specified, but most probably they are of Siemens Bros.' own make. The meters they propose to supply are of the Aron type, but their price for them is exceedingly high. The system of mains they propose to use is, for the arc lighting single cables, vulcanised rubber, covered, armoured with iron wires, and protected outside again ; and for the private lighting, their concentric conductors, cased with lead and armoured with hoop iron. These cables are being laid in considerable lengths by some of the London electric light companies. They require no conduits or pipes, being sufficiently protected from outside damage by their perfect armouring, and are laid simply in a trench. They send no tracing of the run of the mains, but from the length of cable they specify, it would appear they intend to lay a cable under each sidewalk, and their price for the cables and the laying—£4,990—is a moderate one. At the same time, the method of connecting up consumers to a concentric cable is rather expensive. Their price for the public lighting plant, which consists of their own machines, coupled direct to Willans engines, is the highest on the list. They propose, as an alternative tender, to supply their alternators coupled direct to Willans engines, and with the exciter in this case coupled direct to the armature shaft. As referred to before, in the case of Johnson and Phillips, this combination very considerably economises space, and also allows for a perfect arrangement of steam-pipes, but, as we stated before, we do not propose to recommend you to adopt high-speed engines for the private lighting. Messrs. Siemens Bros'. price for dynamos and engines, and sundries to Specifications A and C combined in this way, is £8,950, a distinctly moderate price, but in this sum they only include one feed-water heater for the three engines, instead of three, as specified, consequently saving on the cost of the feed-water heaters, and also of the pipe arrangements necessary with them. Messrs. Siemens Bros., in addition, tender for a low-tension system, which we refer to later on in this report in connection with the other low-tension systems tendered for.

The Westinghouse Company

Only tender for the complete work, without giving separate tenders for each specification. They also give no particulars as to the make of engines ; the electrical machinery being all of their own make. They also propose to supply the Westinghouse alternating-current arc light system. They recommend, in common with several other contractors, the transformer sub-station system of distribution. Their price for the whole of the works is no less than £55,350, which, by substituting Westinghouse vertical high-speed engines for the horizontal engines, and some other slight differences, might be reduced to £51,340—a price which entirely puts their tender out of the question.

Messrs. Drake and Gorham

Tender for the alternators under Specification C, and public lighting plant under Specification H. They give absolutely no particulars of the plant they propose to supply, and consequently we are unable to criticise their tender.

The foregoing finishes the report on the bulk of the tenders sent in, all of which are for the alternating-current transformer system as specified, but two of those contractors whose alternating current tenders have been considered, have likewise sent in alternative tenders for a low-tension continuous-current system, and these two are Messrs. Crompton and Co., and Messrs. Siemens Bros. and Co., and in addition Messrs. Latimer Clark, Muirhead, and Co. have sent in a tender for a continuous-current low-tension system ; only Messrs. Crompton and Co. accompany their tender with a long report on the advantages of a low-tension system, in which they enumerate what they consider to be many points of advantage in favour of it, the principal ones of which are economy in first cost, and increased economy in working, owing to small losses, but after careful consideration we cannot endorse the claims for advantages on this system made by this company. In the first place, the cost is only cheaper when compared with Messrs. Crompton's own estimate for alternating-current plant, and this is not to be wondered at when this firm quote for alternating-current plant, and appliances made by firms other than themselves, and a considerable portion of this supposed economy is attained by putting in boilers of a smaller steaming capacity and a cheaper type than those specified, and running the public lighting lamps off the private lighting plant, instead of providing separate high-tension continuous-current plant for the public lighting, whilst there is an alarming increase in the price of the mains, which is a point to be seriously considered by you, having regard to the extension of the lighting which is sure to take place. Messrs. Crompton's estimate for the mains laid on Crompton's system for low-tension supply is over £10,000, and although this is a very high figure it is remarkably lower than the tender of Messrs. Latimer Clark, Muirhead, and Co. for the mains alone, for the low-tension supply on their system, which is over £20,000, notwithstanding that this latter company's system would appear to us at least as cheap to construct as Messrs. Crompton's. Again, Messrs. Siemens Bros., who submit an alternative tender for the low-tension system, and who propose to lose a much larger amount of energy than that specified by us for the alternating-current system—namely, 10 per cent., as against 2½ per cent.—require for the low-tension plant and mains £35,000, without boilers and buildings, bringing their total tender, when allowing for these latter, to about £44,000, and this, compared with their own estimate for alternating-current plant, after adding an estimated amount for engines, boilers, transformers, and buildings, not included by them in their tender, shows a saving in first cost in favour of the alternating-current system of about £9,000, and as clearly this difference in price in Messrs. Siemens's tender is largely due to the increased cost of mains, Messrs. Crompton and Co.'s deductions in favour of initial cost are not supported by the tenders of the other two firms, and it must be borne in mind that this firm, unlike Messrs. Crompton and Co., propose to supply plant of their own manufacture for either system. Again, as stated above, you will bear in mind that this project is likely to be but a small beginning to your electric lighting system, and that in the immediate future the size of the station will have to be increased. If the cost of the mains for the low-tension system is so great in the first area, the cost of the mains bringing energy into the second area, which is likely to be outside the first one in the direction of Stephen's-green, would most probably be so prohibitive as to make it better worth your while to put down a second generating station in the second area, and thus reduce the cost of the mains, instead of centralising all your machinery until it reaches a fair size in the one station. Secondly, as regards the question of efficiency in working, the system we recommend for your adoption later on in this report will put the alternating system within a few per cent. of the efficiency of the direct low-tension system, without the large outlay, and (as the distance increases) increasing cost of mains.

Messrs. Crompton and Co. make a statement in their report as to their reason for running the public lighting lamps off the private lighting mains instead of providing separate high-tension plant therefor. They say that the running of arc lamps in series involves the use of complicated appliances, and is liable to get out of order, and that after extended trials in the continental cities in Europe, the low-tension system has been found the most regular and economical system of arc lighting for streets. This we regard as a statement likely to mislead you ; it is beyond question that an overwhelmingly large percentage of the public street lighting by electricity is effected on the series high-tension system, and the use of this system is every day extending ; notably, it is a fact that in American cities using the Edison three-wire low-pressure system for private lighting (identically that proposed by Messrs. Crompton and Co.), the arc lighting in the streets and elsewhere is carried out on one or other of the well-known high-tension series system. We would state that we are of opinion that, taking into consideration the conditions that are likely to be met with for the supply of electricity for private lighting purposes in Dublin, you should accept tenders for the carrying out of the work on the alternating-current system. Referring to the proposition made by several contractors as to the grouping of the transformers in five or six sub-stations, consisting of a small cellar or room in which the transformers are placed, instead of having separate transformers in the houses of each consumer, we are of opinion that you will do wisely in arranging to adopt this system. It will involve an extra initial expenditure on the basis of the lower tenders, of about £3,000, but, as pointed out by Messrs. Gordon and Co., the economy achieved by keeping the transformer always fully loaded will be equal to nearly 25 per cent. of electricity sold ; or, looked at from the other point of view, with a very large saving on your coal bill, which will soon recoup the extra money spent initially. This need not interfere with your progress in accepting tenders, as those contractors from whom you order the transformers and mains can alter their prices to the new conditions, on the same basis as the prices tendered for the old conditions, by means of the schedules attached to their tender.

APPENDIX B.

—	——	A Steam engines.	B Boilers.	C Dynamos.	D Reg. apparatus instruments.	E Transformers.	F Meters.	G Cables.	H Public lighting.	I Buildings.	General.	Tender without buildings.
		£	£	£	£	£	£	£	£	£	£	£
A	R. Hornsby and Sons...	5,463	4,640	2,682	671	3,863	570	3,126	4,163	4,726	29,904	25,178
B	Sharp and Kent	6,625	4,460	6,690	665	3,770	1,350	6,500	3,520	None. Approximate cost of buildings £4,000.	—	35,580
C	Johnson and Phillips ...	5,463	5,375	2,682	671	3,867	570	3,126	4,163	4,726	30,639	25,913
D	Edmundson and Co. ...	6,362	4,755	5,830	1,155	2,910	1,190	7,040	5,025	4,850	39,117	34,267
E	Laing, Wharton, & Down	5,890	4,405	5,400	1,055	2,700	1,100	7,040	4,650	4,850	37,090	32,240
F	Electrical Engineering Company of Ireland...	4,408	4,501	4,076	741	3,470	1,227	4,038	4,224	3,381	29,338	26,007
G	Irish House-to-House Company	9,966	4,650	4,023	1,486	4,039	1,118	4,578	5,274	5,602	33,000	31,398
H	Woodhouse and Rawson	3,388	4,610	3,240	861	3,326	1,290	11,985	3,343 8/6	6,060	38,103	32,043
I	Crompton and Co.	4,692	5,294	3,619	624 10/-	3,037	1,360	5,500	3,328	4,200	31354 10/	27,154 10/-
K	Electrical Construction Corporation	8,400	5,006	3,675	730	3,020	—	—	—	—	—	—
L	Ryan and Purcell.........	6,160	4,184	3,025	740	2,755	1,210	3,024	2,350 Extras £1,024, making £3,374.	No tender. Approximate cost of buildings £4,000	—	23,448 Extras £1,024, making £24,472.
M	J. E. H. Gordon	7,605	4,500	3,771	962	See Specification G.	829	12,711 (inclusive of E)	3,763	5,091	35,000	30,000
N	Babcock and Wilcox ...	—	5,003	—	—	—	—	—	—	—	—	—
O	Goolden and Co.	—	—	3,497	492 10/-	3,727	—	—	—	—	—	—
P	Siemens Bros.	—	—	2,540	1,005	—	1,975	4,990	6,500	—	—	—
Q	Westinghouse Company	—	—	—	—	—	—	—	—	—	55,350 Could be reduced to £51,000	—
R	Latimer Clark and Co...	—	—	—	—	—	—	—	—	—	—	—
S	Drake and Gorham	—	—	2,850	—	—	—	—	4,777 10/	—	—	—

A. Engine: 18 high pressure, 32 low pressure, 36 stroke, 75 revolutions per minute, made by themselves; design fair but agricultural in type. Boilers by Babcock and Wilcox. Alternators of the Kapp type, by Johnson and Phillips; substantial design, but armature rotates instead of fields, which is objectionable, and exciter coupled. Switchboard arrangements by Johnson and Phillips, well designed, but no mention of method of regulation. Transformers by Johnson and Phillips, Kapp type, good design. Meters: No particulars are given. Mains proposed either Fowler-Waring or Brooks system, neither of which have been tried in this country for high-tension lighting. Public lighting: Semi high-speed engines of their own make. Brush dynamos. Brockie-Pell arc lamps on lampposts of neat design. Proposed dynamos and arc lamps form an excellent combination. General arrangement of steam and exhaust pipes all right.

B. Davey-Paxman Engines: No particulars. Dynamos: No particulars, probably Goolden type. Exciters uncoupled, speed 380 revolutions. Instruments of their own type. Goolden transformers. Meters and mains: No particulars. Public lighting: No particulars.

C. This tender is identical in every respect, excepting price, with that of Messrs. Hornsby and Son, above described.

D. This tender is identical in every respect, excepting price, with that of Messrs. Laing, Wharton, and Down.

E. Engines: Specification A, no particulars. Alternators: Thomson-Houston, speed 680 revolutions; exciters uncoupled. Switchboards: Thomson-Houston. Instruments by Elliott Bros. Transformers and meters: Thomson-Houston. Mains and distribution not described. Public lighting: Thomson-Houston dynamos. Engines: No particulars.

F. Engines by Combe, Barbor, and Combe, of Belfast. Cylinders, 14in. and 22in.; stroke, 36in.; speed, 90 revolutions. Boilers: Babcock and Wilcox. Dynamos: Mordey-Victoria, 400 revolutions. Exciters (Victoria) uncoupled, guaranteed efficiency, 90 per cent. Switchboard by Brush Company, with Nalder or Evershed instruments. Hand and automatic regulating apparatus. Sir William Thomson galvanometer and Wheatstone bridge. Mordey-Victoria transformers. Ferranti meters. Callender-Webber system of mains. Public lighting by three Brush dynamos, and engines by Davey, Paxman, and Co. Semi high-speed engines; cylinders, 7in. and 11in. diameter, 8in. stroke.

G. Engines: No maker stated. High-pressure cylinder, 17½in. diameter; low pressure, 27½in. diameter. Stroke, 36in. Speed, 80 revolutions. Dynamos (exciters uncoupled) Lowrie-Hall system, 350 revolutions. Regulating apparatus: Lowrie-Hall; automatic and hand regulation in addition. Well-designed switchboard, House-to-House system. Instruments by Thomson, of Thomson and Cardew type. Transformers of the Lowrie-Hall type. Meters: Lowrie-Hall, Ferranti, or Shallenberger; Mains: Cast iron with junctions and surface-boxes, vulcanised rubber insulation. Engines for public lighting, 7¼in. and 11¼in. diameter; 10in. stroke; speed of 220 revolutions, no maker's name stated. Dynamos for arc lighting in series. Dynamos with automatic current regulation, 800 revolutions per minute. Brockie-Pell arc lamps. Lampposts of plain design.

H. Engines of their own make. Cylinders (high pressure) 12in., and (low pressure) 22in.; stroke, 24in. Speed, 90 revolutions. Alternators: Kingdon type of their own make. Instruments of their own make, but non-inclusive of synchronising appliances. Transformers of the Brush make. Meters of the Ferranti-Wright type. Mains: Cast-iron pipes and vulcanised rubber cables, Silvertown make. Public lighting: Engines of their own manufacture. Brush dynamos supplying current to Brockie-Pell lamps on ornamental cast and wrought iron lampposts. Only two sets of public lighting plant of sufficient size to do all the work between them have been included, instead of three as specified.

I. Engines by Pollitt and Wigzell. High pressure, 17½in.; low pressure, 28½in.; stroke, 42in. Boilers: Excelsior or Mills. Alternators by Goolden and Co.; speed, 400. Exciters of their own make, uncoupled. Regulating apparatus operated by hand; no mention of makers of instruments. Transformers of the Statter type. Meters of the Aron type. Mains: Vulcanised rubber cables laid in cement concrete conduits. Public lighting engines by Davey, Paxman, and Co. Generators of their own make, with Statter's constant-current regulating apparatus. Arc lamps, Crompton-Crabbe, mounted in lanterns on lampposts of exceedingly handsome design.

K. Engines: No particulars. Boilers: Babcock and Wilcox. Alternators: Their own make, with their own exciters uncoupled. Hand regulating apparatus, with instruments by Sir William Thomson, Cardew, and Elliott Brothers, but no recalibrating apparatus included. Transformers of their own make.

L. Engines by Fowler and Co., Leeds. High-pressure, cylinder, 17½in.; low-pressure, 27½in.; stroke, 36in. Flywheel, 15ft. diameter; feed-water heaters by Kirkaldy and Co. Babcock and Wilcox boilers. Steam-pipes by Worthington Pump Company. Alternating-current dynamos of the Statter patent type; stationary magnets, revolving armatures, speed under 400 revolutions. Exciter coupled direct, very complete arrangements, automatic and hand regulation gear. Switchboards: House-to-House Company's type. Instruments by Sir William Thomson, Cardew, and Elliott Brothers. Transformers of the Statter type in water-tight iron casings. Meters of the Ferranti type. Mains highly insulated, vulcanised covered cables with junctions. Public lighting engines: The Gwynne or Allen type compound, 220 revolutions per minute, continuous current. Dynamos: Statter type, with automatic regulation. Arc lamps: Statter type in lanterns.

N. Engines by Robey and Co., with automatic trip expansion gear: High-pressure cylinder, 17½in.; low-pressure, 30in.; stroke, 40in.; speed, 75 revolutions. Boilers: Mills or Excelsior.

Dynamos: Lowrie-Hall-Ellwell-Parker manufacture, 350 revolutions. Exciter uncoupled. Switchboards same type as used by Metropolitan Electric Supply Company, Manchester-square station. Instruments by Goolden and Cardew. Hand regulating apparatus. No synchronising appliances. Mains in earthenware pipes, with patent Archer joints, and highly-insulated vulcanised rubber cables, arranged either on the sub-transformer system or as per specification. Meters of the Westinghouse type. Public lighting engines by Robey and Co., vertical side by side compound, 220 revolutions per minute, driving either Brush or Thomson-Houston dynamos, feeding either Brockie-Pell or Thomson-Houston lamps.

N. Quote for boilers and feed-water heaters only.

O. Alternators of their own manufacture. Instruments of their own and Cardew's manufacture. Transformers of their own make.

P. Alternators of their own type, speed 400 revolutions per minute. Exciters uncoupled, and rope-driven. Switchboards by themselves. Instruments: No particulars. Aron meters. Siemens' single and concentric cables. Public lighting: Siemens machines coupled to Willans, engines running Siemens arc lamps on ornamental posts.

Q. Engines; 15in. high pressure, 24in. low pressure, 36in. stroke; 90 revolutions. Alternators: Westinghouse. Exciters: Uncoupled. Instruments: Westinghouse. Meters; Westinghouse. Mains: Cast-iron pipes and vulcanised rubber, highly insulated cable. Public lighting: Westinghouse alternating-current system. No particulars of engines.

S. Alternators: No particulars. Public lighting plant: No particulars.

APPENDIX C.

68, Victoria-street, Westminster, S.W.,
London, 1st August, 1890.

To the Electric Lighting Committee of the Dublin Corporation.

Proposed Dublin Electricity Supply, 1890.

Gentlemen,—In accordance with instructions received from the town clerk and borough surveyor, I have gone carefully into the question of the electricity supply for public lighting purposes in the compulsory area embraced in your license for public lighting, and the supply for private lighting purposes embraced in your license for private lighting, and I now have pleasure in enclosing you herewith two specifications, estimates, map, and plans.

The specifications are for two schemes—one on the assumption that a central station is put down with sufficient plant to provide current for 80 arc lamps of about 1,000 c.p. each, and 3,000 incandescent lamps of 16 c.p. each; the other on the assumption that power is provided for the same number of arc lamps for the public lighting, but with sufficient power and enlarged mains for the supply of current to 5,000 lamps of 16 c.p. each for the private lighting.

You will notice by the estimates, which have been very carefully drawn up by me, that the cost of the larger station, mains, etc., is about £50,000, and of the smaller station, mains, etc., about £37,000. The estimate for the smaller station is naturally higher in proportion than for the larger station, as many of the works would be identical for both to allow for the extension of the smaller station should you determine to start with that.

Both specifications have been drawn up in a manner that, while stipulating the conditions that have to be fulfilled by the contractor, a free hand is left him in suggesting the details of his own scheme, and I have done this in accordance with your instructions.

The Fleet-street site would be well adapted for the carrying out of either scheme, and one of the plans accompanying this, and intended to go with the specifications, shows the arrangement of the plant I would propose for either scheme.

The large map accompanying this, and which shows in one colour the compulsory area, and in another the extension you propose to make, is marked with the run of the mains and the distribution of lights for both public and private purposes, as you will probably find to be the case in actual practice.

The number of lamps and their arrangement allowed for the public lighting is, in my apinion, amply sufficient for the perfect illumination of those streets, and sufficient amount of spare plant is allowed to effectually guard against chances of a breakdown. The circuits are so arranged that each alternate lamp is on a different circuit, and the temporary extinction of one circuit would not interfere with the public convenience.

I have provided for the private lighting being carried out on the alternating-current transformer system, which I consider to be the best for the supply of current for private purposes in Dublin, and I believe from what you have seen of the lighting by electricity at present in use in the United Kingdom, you have satisfied yourselves on this point.

The following are my estimates of the probable revenue and costs for working for the two installations—viz.:

Cost of Maintenance of a Central Station for 80 Public Lights, 1,000 c.p. each, and 3,000 Private Lights of 16 c.p. per annum.

Capital cost about £37,000.

Labour—Superintendent		£300	0	0
4 engine drivers	per week, 30s.	312	0	0
2 assistants	,, 20s.	104	0	0
4 stokers	,, 20s.	208	0	0
4 linesmen	,, 30s.	312	0	0
1 fitter	,, 40s.	104	0	0
1 assistant fitter	,, 30s.	78	0	0
2 meter attendants	,, 25s.	130	0	0
3 arc lamp trimmers	,, 20s.	156	0	0
Drawing and office expenses	,, 60s.	156	0	0
Coal for 840,000 h.p. hours, at 4lb. per h.p. hour, about 1,500 tons, at 18s.		£1,350	0	0
Oil, water, and waste, 15 per cent. off cost of coal		202	10	0
Repairs and sundry materials, say, 5 per cent. on £37,000		1,850	0	0
Carbons for 320,000 arc lamp hours, at ¾d. per lamp per hour		1,000	0	0
		£6,262	10	0

Allowing that on an average 10 per cent. of the 3,000 lamps are burning day and night, 129,600 Board of Trade units will be sold on this account; and that the balance of the 3,000 lamps are burning on an average 1,000 hours per annum, 162,000 Board of Trade units will be sold on this account; or together 291,000 Board of Trade units; that at 7d. per unit will yield a gross revenue of £8,487. 10s., from which the annual maintenance charges of £6,262 have to be deducted, leaving a net revenue of £2,221.

You will, however, notice that nothing has been allowed for the cost of the public arc lighting, and it is fair to assume that this will cost you at the rate of £20 per annum for each arc lamp, or for the 80 lamps, £1,600, and this has to be added on the net revenue of £3,821.

Cost of Maintenance for a Central Station for 80 Public Lights of 1,000 c.p. each, and 5,000 Private Lights of 16 c.p. each per annum.

Capital cost about £50,000.

Labour—Superintendent		£300	0	0
5 engine drivers	per week, 30s.	390	0	0
3 assistants	,, 20s.	156	0	0
5 stokers	,, 20s.	260	0	0
4 linesmen	,, 30s.	312	0	0
2 fitters	,, 40s.	208	0	0
1 assistant fitter	,, 30s.	78	0	0
3 meter attendants	,, 25s.	195	0	0
3 arc lamp trimmers	,, 20s.	156	0	0
Drawing and office expenses	,, 80s.	208	0	0
Coal for 1,160,000 horse-power hours, at 4lb. per horse-power hour, about 2,080 tons, at 18s.		1,872	0	0
Oil, water, and waste, 15 per cent. of cost coal		280	10	0
Repairs and sundry materials, say, 5 per cent. on £50,000		2,500	0	0
Carbons for 320,000 arc lamp hours, at ¾d. per lamp per hour		1,000	0	0
		£7,915	10	0

Allowing as before that on an average 10 per cent. of the 5,000 lamps are burning day and night, 180,000 Board of Trade units will be sold on this account; and that the whole of the 5,000 lamps are burning on an average 1,000 hours per annum, 300,000 Board of Trade units will be sold on this account, or together 480,000 Board of Trade units; that at 7d. per unit will yield a gross revenue of £14,000, from which the annual maintenance charge of £7,915 has to be deducted, leaving a net revenue of £7,085.

As before, the cost of the arc lighting—viz., £1,600—must be added to this, making the real net revenue £8,685.

Of course the approximation of the revenue depends upon the actual amount of light that will be consumed, but I think the figures I have given you, and which are founded on the results of actual working, may be relied upon, as there can be little doubt that lighting will be taken up vigorously by the citizens of Dublin.

I remain, Gentlemen, yours faithfully,

E. MANVILLE, per S.W.

COMPANIES' MEETINGS.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY.

The twenty-seventh ordinary general meeting of this Company was held at the Cannon-street Hotel on Thursday, the chairman, Mr. S. W. Silver, presiding

The **Secretary** (Mr. W. J. Tyler) having read the notice convening the meeting,

The **Chairman** said the report (*vide* our last issue) had been in their hands, and he presumed they would take it as read. He would rise to move that the report be received and adopted. In doing so, he would remark that since they had the pleasure of meeting the shareholders, the works had been well employed, and they had found ample requirements for all their capital. The report showed the result to be very satisfactory; and this notwithstanding the keen competition met with in obtaining orders, and the price of the raw material having considerably advanced. This he need not say had affected the rate of profit. In the submarine telegraph branch they had manufactured during the year upwards of 2,000 miles of cable, and he would remark that the item referred to under the head of stock as cable on account of contracts, had just been successfully laid by their staff on board the "Silvertown," off the west coast of South America. The day-by-day trade of the Company had increased, being over half a million for the year. He was glad to say that the prospects for this year were as satisfactory, and they had several cable contracts in view. These remarks applied equally to Persan as to Silvertown. In asking them to adopt the report, he would recommend an addition being made to the reserve fund, which supplied them with the sinews of war, and took the place of a considerable increase which would have to be made in the capital of the Company. The result of this (supposing the capital to be increased), he need not remind them, would seriously affect the dividend by increasing the number of those who shared it. The freehold buildings and the machinery had been maintained and were in the highest state of efficiency. They had in their operations at Silvertown evidence that capital and labour, when combined with judgment and well-directed energy, could be made to render a fair return to the investor for his money, and a just remuneration to the employed. He then moved the adoption of the report and accounts, and the payment of a dividend of 10s. per share, free of income tax, payable on and after the 20th inst. (to-day).

This was seconded by **Mr. A. W. Jarvis, M.P.**, and adopted, after some discussion.

Resolutions were then carried re-electing Messrs. Bannatyne and Henderson as directors, and Mr. Weise (of Turquand, Young, and Co.) as auditor.

COMPANIES' REPORTS.

CITY AND SOUTH LONDON RAILWAY.

The report of the Directors for the half-year ending December 31 states that the railway has been completed, and was opened for public traffic on December 18 last. Since that date a service of trains, running at intervals of about five minutes, has been maintained, and although there have been a small number of occasional delays from the failure of engines and other causes, there is every reason to be satisfied with the use of electricity as a motive power, and when the various improvements suggested by experience are all carried out it is anticipated that the line will prove one of exceptional safety and comfort, and will be worked with economy and regularity. During the short time the railway has been working the average number of passengers carried has been about 15,000 per day, but as the weather improves and the line is better known this number will no doubt steadily increase. It has been found in working such a rapid service that the siding accommodation provided is insufficient, and arrangements are now in progress for the construction of additional sidings at the Stockwell terminus, which will add greatly to the facilities for working the line. The accounts for the past half-year have been made out in the form previously adopted, but as the Company is now recognised as a railway, the accounts in future will be rendered in the form prescribed by the General Railway Acts. As the line was only opened a few days before the close of the half-year, it has not been thought necessary to create a separate revenue account for that short period.

CITY NOTES.

City and South London Railway.—The receipts for the week ended February 14 were £702.

Brazilian Submarine Telegraph Company.—The receipts for the week ended February 13 amounted to £5,538.

Commercial Cable Company.—The Company's general offices in London have been removed from 29, Threadneedle-street to 18, Bishopsgate-street Within, E.C.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 13, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £4,493.

Woodhouse and Rawson.—This week Woodhouse and Rawson United, Limited, invited applications for 20,000 ordinary £5 shares and 10,000 preference £5 shares, entitled to a preference as to capital and to 7 per cent. preferential cumulative dividend per annum, together with a further 1 per cent. in every year in which the ordinary shares have received a dividend of 10 per cent. or upwards. There were also £100,000 5½ per cent. 1891 debenture stock (part of a total issue of £200,000), which is created partly to pay off the existing 6 per cent. debentures, and partly to pay off the balance of the sum deposited with the Company as a guarantee fund. The list closed on Wednesday.

PROVISIONAL PATENTS, 1891.

FEBRUARY 9.

2334. **Improvements in and relating to electrical communicators for use on public vehicles and the like.** John William Eyre and Charles Graham, 389, Kennington-road, London.

2360. **Improvements in or relating to accumulator plates.** Henry Tyrer Cheswright, 323, High Holborn, London. (Complete specification.)

FEBRUARY 10.

2417. **A new or improved voltmeter and ammeter.** Joseph Matthews and George Birrell Cruickshank, 7, Staple-inn, London.

2418. **Improvements in electric accumulators or storage batteries.** Joseph Matthews and George Birrell Cruickshank, 7, Staple-inn, London.

2431. **Improvements in safety appliances applicable with switches, fusible cut-outs, or other electrical circuit-breakers, for the prevention of flashing or sparking across from one conducting part to another.** John Alexander Colquhoun, 6, Lord-street, Liverpool.

2446. **Improvements in or connected with means or apparatus employed in electrolysis.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (George D. Davis, United States.)

FEBRUARY 11.

2471. **The manufacture of hydrolised lead cells for electrical or storage batteries.** Thomas William Bush and Matthew Doubleday, Loughboro'-road, West Bridgford, Nottingham.

FEBRUARY 12.

2518. **An improved method of depositing copper or other metals by electrolysis, with the object of refining it or them, or of recovering the precious and or other metals contained in or alloyed with the metal under treatment.** William Gibbings, 23, Island-road, Garston, Lancashire.

2522. **Improvements in attachments or fittings for electric light sliding pendants, electroliers and stand, and other extension lamps.** William Reuben Lane and John Cottrell, 6, Livery-street, Birmingham.

FEBRUARY 13.

2642. **Improvements in telephone receiving instruments.** Ernest Jules Pierre Mercadier, 55, Chancery-lane, London.

2654. **Improvements in primary batteries** Sir Charles Stewart Forbes, Baronet, 21, Finsbury-pavement, London.

2664. **Improvements in machinery for cutting coal or other minerals, driven by electricity.** Llewelyn Birchall Atkinson and Claude William Atkinson, 1, Queen Victoria-street, London.

FEBRUARY 14.

2677. **Improvements in meters for measuring, registering, and recording electrical currents, in part applicable to other measuring and recording instruments.** Charles Algernon Parsons, 13, Temple-street, Birmingham.

2689. **An improved ceiling rose, or connector for electrical circuits, and for the suspension of electrical fittings, and similar purposes.** Edward William Lancaster, Albert Works, Graham-street, Birmingham.

2706. **Making joints and connections in concentric cables, or mains for conveying electric currents.** Arthur West Heaviside and Robert Cattley Jackson, 7, Grafton-road, Whitley, Northumberland.

2714. **Improvements in electric lighting and for other like purposes.** Robert James Ray, 85, Gracechurch-street, London.

2732. **Improvements in flexible supports for electric lamps.** William White, 28, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1878.

2396. **Telephones.** Edison. (Third edition.) 1s. 1d.

1889.

19892. **Welding metal by electricity.** Fowler. (Amended.) 6d.

1890.

1031. **Electric Compass, etc.** Von Peichl. 8d.

2659. **Electric arc lamps.** Parsons. 8d.

3969. **Electrical switchboards.** Siemens Brothers and Co., Limited. (Taylor.) 6d.

4053. **Safety devices for electrical currents.** Drake and Gorham 6d.

4275. **Electrical switches.** Kingdon. 8d.

4921. **Galvanometers.** Perry. 4d.

7670. **Electric meters.** Abel. (Société Anonyme Continentale pour la fabrication des Compteurs à Gaz et autres appareils.) 11d.

13904. **Electric railways.** Dewey. 8d.

16570. **Electric motors.** Groswith. 6d.

18699. **Electric circuit closers.** Thomson and von Kohler. 6d.

19806. **Incandescent electric lamps.** Marshall. 6d.

21026. **Electrical railway switches.** Berne and Fish. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	1½
Swan United	3½	5
St. James'	—	6
National Telephone	5	4¾
Electric Construction	10	7¼

NOTES.

Rawtenstall.— The surveyor has been requested to prepare estimates for more light.

Orleans.—The subway station of Orleans is to be entirely lighted by electric light upon the Ganz system.

Bideford.—The question of better lighting the town of Bideford is occupying the attention of the Town Council.

Folkestone.—The Lighting Committee of Folkestone are resorting to arbitration to fix the price of their public lighting by gas.

Tivoli.—One of the last acts of Signor Crispi was, we understand, to issue a decree for the utilisation of part of the celebrated Falls of Tivoli for public electric lighting.

Hull.—The deputation from Hull which visited Bradford has reported very favourably; advise the Corporation to undertake the supply, but are unable as yet to definitely recommend a system.

Gordon's College, Aberdeen.—The committee have agreed to purchase a gas engine for £235, and enquiry was ordered to be made as to the relative cost of lighting by gas and by electricity.

Endolithic Ivory.—The Endolithic Ivory Company, Limited, were awarded the only prize medal and diploma for address tablets and switchboard labels at the exhibition lately held in Edinburgh.

Stratford-on-Avon.—A handsome new post office will be erected at Stratford-on-Avon this year. As it is usual for new post offices to have the electric light, plant will probably be required here.

Barking.—The public lighting of Barking, Essex, is carried out by means of oil. A deputation recently asked the Local Board to introduce gas. While they are about it electric light might be applied.

Heckmondwike (Yorks.).—At the last meeting of the Barnsley Town Council it was announced that the Westinghouse Electric Lighting Company were not willing to undertake the lighting of Heckmondwike.

Dungarvan.—The wretched state of the lighting of Dungarvan, Waterford, now carried out by oil, is exciting the attention of the Town Commissioners, who are inviting tenders for other means of illumination.

Brush Dividend.—The Brush Electrical Engineering Company have issued warrants for an interim dividend on the preference shares for the half-year ended 31st December last, at the rate of 6 per cent. per annum.

Paris Concessions.—An amalgamation under direction of the chief bank of Paris—something similar to what has taken place in the City of London—is said to be expected between the various companies holding concessions for lighting the various sections of Paris.

Electricity in Physiology.—Before the Royal Society, yesterday, the Croonian lecture was delivered by Mr. F. Gotch and Prof. Victor Horsley, F.R.S., "On the Mammalian Nervous System, its Functions and their Localisation Determined by an Electrical Method."

Durban.—Durban has still to depend upon oil lamps for its illumination, but with this state of affairs dissatisfaction is now being freely discussed. The question to be decided is, and it is being argued with some spirit in the local newspapers: Is it to be gas or electricity?—*Gas World.*

Chiswick.—The Works Committee of the Chiswick Local Board report that with regard to the amended provisional order for Chiswick electric lighting, the only clause that had been inserted on objections made was the saving clause of the Thames Conservancy, to which the Board did not object.

Water at St. James's.—The borings for water in Mason's-yard for the St. James's Electric Light Company, have proved extremely successful, and the yield is now over a million gallons a week. The parish intend to imitate the example, and use the water for baths and for cleaning the streets.

Marseilles.—The Gas Company of Marseilles are erecting several central stations for electric light, the power for which is provided by means of large gas engines which are to be used to charge accumulators. The company is wise in its generation—dividends from both gas and electricity may be now expected.

Westinghouse Company.—The financial troubles encountered by the American Westinghouse people is, according to the latest papers, now over, and a brisk demand is maintained for Westinghouse stock. The recovery of prices is good for all, as the shares of the other electric companies were beginning to decline out of sympathy.

Bedford.—The Corporation of Bedford, having obtained a provisional order, invite tenders, as will be seen from their advertisement elsewhere, for the public lighting of the borough for a term of years, at a price per lamp, the contract carrying with it privileges for supplying private lighting and power. Tenders will be received until March 31 next.

Portsmouth.—The Portsmouth Electric Lighting Committee have decided to recommend the Town Council to take the management of the electric lighting works in the borough, instead of leasing the powers granted by the Corporation to a private company. The Council is asked to adopt the low-tension system, to avoid the danger of overhead wires.

Air Ship.—Messrs. Siemens and Halske have undertaken the electrical apparatus for an airship, which is to be exhibited at the Frankfort Exhibition in the shape of a large dirigible balloon for carrying 10 persons. The balloon will be connected by a telephone, and the gas will be generated by electrolysis, the arrangements being suitable for war balloons.

Lynton.—The electric light, which has been entirely absent from Lynton and Lynmouth since Christmas, reappeared at Lynmouth last week, and has been satisfactory there, but has failed to reach Lynton. An electrical engineer has recently tested the wires, and reports that the joints are in a very defective state. The matter is being attended to with all speed.

Electrically Welded Projectiles.—The Thomson Electric Welding Company have decided to organise the American Projectile Company, with a capital of half a million dollars, to manufacture electrically welded shells out of seamless tubes and solid pointed ends. Large Government contracts are secured, and the buildings and plant will be ready within two months.

Cambridge University.—The new Professor of Engineering at Cambridge (Prof. Ewing), is already making extensions at the university in the interest of his department. A steam engine and other apparatus necessary for a laboratory of engineering and applied electricity are to be supplied at a cost of £500, and a second demonstrator is to be appointed, at a stipend of £150 per annum.

Cantor Lectures.—The third and last of Mr. Kapp's lectures on "The Electric Transmission of Power" will be given before the Society of Arts on Monday, 2nd March, at eight o'clock. Syllabus of Lecture III.: Limit of Dis tance to Direct-current Transmission—Alternating-current Transmission—Synchronising Motors—Ferrari's Motors—Motors for Small Powers—Electric Machine Tools.

Hyde Park Corner.—The high-class lighting at Hyde Park Corner is costing the Gas Light and Coke Company £160 more a year than it receives for it from the St. George's Vestry. The Vestry objects to pay this sum, but it wants to retain the light. The electric light company has refused to take the place of the gas company, and the Vestry has offered the gas company £50 a year to continue the lighting.

Huddersfield.—At a monthly meeting of the Huddersfield Town Council held last week, a report which had been presented by the Electric Lighting Sub-Committee, with respect to the different systems of electric lighting which had been investigated, was adopted, and the town clerk received instructions to write to the town clerk of Birmingham for information with respect to the system of electric lighting adopted in that city.

Electric Fire at the Czar's Palace.—On the 18th inst. the Czar, according to a Reuter's telegram, being in his Anitchoff Palace, St. Petersburg, noticed a smell of burning, and saw clouds of smoke coming from the apartments of the Empress. The flames were subdued by the firemen after destroying some valuable paintings, statues, and tapestry. The fire is rumoured to be owing to the defective fixing of electric light wires.

Molecular Resistance.—M. P. Joubin has undertaken researches upon the physical properties and the molecular constitution of simple metallic bodies, which he divides into two groups—diamagnetic and magnetic metals. According to the results he has obtained, all the physical properties of the metallic bodies of the same group would depend exclusively on the distance of their molecules, the two groups being distinguished by the relative conductivity of their molecules.

Telephoning Telegrams.—The Western Counties and South Wales Telephone Company have for some weeks made arrangements, at the request of the Plymouth Chamber of Commerce, that subscribers can call upon No. 199, the Plymouth Post Office, and dictate their telegrams, which are thus sent direct—with great saving of time and trouble—the only condition being that the subscriber must have a suitable deposit at the post office against the cost of such telegrams.

Newport (Mon.).—At the meeting of the Newport Town Council on Monday last the Mayor moved a formal resolution that the Council approve and authorise the application for a provisional order to supply electricity within the borough. Mr. Howell thought the opinion of the ratepayers should be taken before £30,000 was spent on electric light. It was explained that the Corporation had no choice but to take powers, otherwise a private company would come and pull up the streets. The proposal was carried.

Electricity to the Rescue.—A destructive fire broke out last Sunday at Maids-Moreton Lodge, near Buckingham, the residence of Baroness Kinloss and Captain Luis Morgan Grenville. The butler gave the alarm and Baroness Kinloss and family were removed from the building, and the servants had a narrow escape, the residence at this time being full of smoke. Captain Morgan had recently had the place lighted by electricity, and, this being turned on, the inmates by its aid were able to escape.

Electrical Purification of Sewage for Paris.—There are now in Paris, points out the *Bulletin Internationale de l'Electricité*, central stations representing 26,000 h.p. not utilised for the greater portion of the day, and it would seem that the expense would be less to the ratepayers if the city machinery were to be used for the purification of the sewage, the effluent of which could be simply run back into the Seine, instead of the costly scheme proposed of taking the sewage to irrigate Normandy.

Cleckheaton Town Hall.—At a meeting of the Cleckheaton Town Hall Committee it was unanimously resolved to accept the recommendation of a sub-committee to light the Town Hall premises by electricity. This would involve an extra initial outlay of about £500, but it is thought that electricity would be preferable alike in point of cleanliness, health, and general suitability, and that it would ultimately save a good deal of expenditure in cleaning and redecoration. The proposal yet requires the sanction of the Local Board.

Birmingham Inspectorship.—With reference to the report of the Birmingham committee on electric testing, given in another column, the committee have ascertained that Mr. Henry Lea (Messrs. Lea and Thornbery) is willing to discharge the duties of electric inspector for 12 months at a salary of £150, and they recommend that he should be appointed. The committee are conferring with Mr. Lea as to the position, etc., of the testing station, and the fees to be prescribed as the fees to be taken by the inspector and by him paid to the credit of the borough rate.

Madrid.—The Madrid Chamber of Deputies will shortly be lighted by electric light from its own installation. The Senate House will, however, be supplied from the company's mains. The inhabitants of Madrid seem to be much in favour of the electric light, as orders to be connected come in by great numbers every day. Unfortunately, it is stated, many of them do not remain customers more than sufficient time to just be able to say they have had the light, on account of the high price—1s. 3d. per 1,000 watt-hours—that the company at present charge for the current.

Paris.—The celebrated clothing store in Paris which goes by the honoured name of "Old England" (amusingly pronounced something like "Oll Donglong"), has recently been lighted throughout by electricity, by means of Cance arc lamps. The installation comprises 14 lamps taking eight amperes and 22 lamps of six amperes, enclosed in small opal glass globes, besides 50 16-c.p. incandescent lamps. The current is supplied from mains of the Place Clichy, which are run on the Siemens five-wire system. The installation is provided with an elaborate switchboard and protective appliances.

Obituary.—It is with exceedingly great regret that we hear of the loss sustained by Mr. W. T. Glover in the death of his wife at the early age of 36 years. Mrs. Glover passed away after a protracted illness on the 23rd February, and will be buried to-day at St. Paul's Church, Kersal. Many of the numerous friends of Mr. Glover have participated in his hospitality at Moorhurst, and will sympathise with him in his hour of trial, knowing the great interest taken by the late Mrs. Glover in all that concerned the welfare of electricity and in the doings of the prominent members of the industry.

Definitions.—Lord Salisbury, besides being an able statesman, is a scientist, and often a witty one. This characteristic was amusingly illustrated in his speech to celebrate the jubilee of the Chemical Society on Wednesday, when he gave some novel definitions of modern science. "I should say," said his lordship, "that astronomy is largely the science of things as they probably are. Geology consists mainly of the science of things as they probably were. Chemistry is the science of things as they actually are." To this we may add that electricity is the science of things as they probably will be.

Subway for Submarine Cables.—In addition to Sir Edward Watkin's Channel Tunnel scheme, and Sir Edward Reed's tube tunnel, a third plan has been projected, and has been submitted for the consideration of the Postmaster-General. This consists of a tunnel bored much on the lines of the South-Eastern project, but the bore not to be of greater magnitude than necessary to convey the mails, and find room for the telegraph wires, thus avoiding the expense of cable lines. It is claimed that the adoption of this scheme would save two hours in the transmission of continental mails, whilst it would add considerably to the certainty of the service.

Electric Tramway at Acton.—The Acton Local Board at their last meeting had before them a letter from the secretary of the West Metropolitan Tramway Company, asking permission to apply electricity as the motive power of this company's cars on the portion of their system under the control of the Board, and stating that the slot was now entirely dispensed with, and that the Board could see the system in full operation at any time. The clerk read a copy of the agreement between the Hammersmith Vestry and the company. Mr. Lewsey proposed that the sanction of the Board be given, subject to the same conditions being carried out as proposed between the Hammersmith Vestry and the company, suitable to the case of Acton. The details were left to the Works Committee.

Liverpool Assistant Electrician.—Owing to the rapid increase in the amount of electric testing and inspectional work carried out by the Liverpool inspection department, which has followed upon the extended operations of the Liverpool Electric Supply Company, Limited, a general assistant to the Corporation electric inspector has been appointed. After some discussion, Mr. Herbert James Roscoe was awarded the situation subject to the usual provisions as to superannuation, etc., and was instructed to commence duties on the 11th inst. Mr. Roscoe was, until the time of his appointment, in the employ of the Liverpool Electric Supply Company, Limited, a company which has probably a larger output than that of any other using the simple parallel system of distribution at low pressure.

Ferranti Mains.—The Highways Committee of the London County Council have considered a notice from the London Electric Supply Corporation of intention to lay trunk mains across Cockspur-street and into Red Lion-yard, where the company has a distributing station. There appears to be no objection to what is proposed, and they recommend that the sanction of the Council be given to the laying of the trunk mains referred to upon condition that the company do give two days' notice to the Council's chief engineer before commencing the works; that the mains, where laid under the footways, shall be kept 2ft. below the underside of the paving, and where they cross the carriageway at the same depth below the concrete, or if this be found to be impracticable, that the mains be protected from mechanical injury to the satisfaction of the Council's chief engineer.

City Lighting.—A meeting of the City Commission of Sewers was held on Tuesday at Guildhall. The Streets Committee laid before the Commission a letter from the Board of Trade intimating that they were satisfied that the Brush Electrical Engineering Companies were in a position to discharge the duties and obligations imposed upon them by the City of London (Brush) Electric Lighting Order, 1890. Mr. Morton, M.P., asked whether the Commission were dealing with the two companies with whom they had contracted in regard to the electric lighting of the City, or with the company of which the Lord Mayor was chairman. The chairman said that, as he understood the matter, they had nothing whatever to do with the latter company. In a discussion which followed, it was stated that the company hoped to be able to light Queen Victoria-street and Cornhill within the next two months.

Copenhagen.—The contract for the establishment of an electric central station for Copenhagen, which was obtained by Messrs. Siemens and Halske, will be commenced this spring. It is to be ready for next winter's lighting. The station is to be for 14,000 16-c.p. lamps, the site being right in the centre of the town. The plant will comprise seven multitubular boilers and three steam engines. Each of the latter will drive two compound dynamos, coupled in sets of two in series. The total capacity is 611 kilowatts. The mains will form a three-wire network with feeders. From the station to the centre of the distribution the loss will be 28 volts, and from each distributive centre to the last lamp another three volts. The lamps will be 110-volt lamps, consequently the total voltage will be 251 volts. The machinery will be used during the daytime to charge Tudor accumulators, capable of giving a current of 250 amperes. Other batteries will be added as the demand increases.

Swansea.—The Electric Lighting Committee of the Swansea County Council reported that a communication from Messrs. Crompton and Co. was read, stating that they could only undertake the work of electric lighting on a 21 years' lease; the schedule of prices to be subject to revision at intervals of seven years. The committee, however, were not prepared to entertain those terms. The town clerk was directed to invite the following gentlemen to personally appear before the committee, and give the committee, gratuitously, the benefit of their advice and experience in electric lighting: Mr. J. C. Howell (of the Crompton-Howell Company), Llanelly; Mr. Alex. Sinclair, Swansea; Mr. J. S. Brown, Swansea. Mr. Sinclair and Mr. Brown attended, and the question of public street lighting by electricity was discussed, and the committee recorded their thanks for the information given by the above-named gentlemen. Mr. J. C. Howell, being absent from the country, was unable to attend.

Petitions.—The Brush and other electrical companies have presented petitions to the London County Council against the General Powers Bill; and from the various railway companies and the National Telephone Company against the London Overhead Wires Bill; also against the various electric subway railways—Central London, South London, and South Kensington—by all manner of authorities, from the Dean of St. Paul's and the City Guilds Institute, New River Company, Bank of England, to the Duke of Portland and the Vestry of St. Luke's. One of the most amusing of these was from some petitioners along the route, who object to the "whistling of the engines," that might disturb them—forgetting, or not knowing, that the locomotives were 50ft. under ground. The usefulness of these electric railways to relieve the enormous and growing traffic of London streets is, however, becoming gradually realised, and it is only probable that most of these petitions will be dropped without challenge.

Northampton.—Mr. Crompton, who is the consulting engineer to the Northampton Electric Company, has inspected the works at Angel-lane, and tried the plant working at full load. This trial was in every way satisfactory, showing that the work has been done well. The directors who were present at the trial were pleased to find that there was so little vibration from the machinery as not to be felt at all outside the building, especially as there has been some talk of possible annoyance to neighbours from this cause. The first portion of mains for the supply current will be completed in a few days, the culverts for these having been constructed by Messrs. Green Bros., under the superintendence of Messrs. Crompton and Co.'s engineer, who put in the copper mains. This part of the work, which is at any time a tedious process, and fraught with inconvenience to the public, has been much retarded by the late prolonged frost. The residents will now, however, be rewarded by the facility for both light and power afforded by the electric light company along the route. The directors have appointed Mr. B. R. Beale, A.M.I.C.E., who has superintended the erection of all the company's works, to be their chief engineer.

Storage Cars Replace Overhead Lines.—In the present state of accumulator traction in England, it may be interesting to note that a contract has been made with the Accumulator Company for the equipment of the new branch of street railroad in Washington with six storage battery cars. This tramway company was one of the first street car roads in the United States to adopt electricity as a means of propelling its cars, and the Thomson-Houston system of trolley wires was installed there several years ago. Congress, however, will not permit the railway company to erect any more trolley poles, particularly in the heart of the city, and this storage battery system has been adopted. The Edco system, which is to be adopted, is the invention of Mr. W. W. Griscom, the president of the Electro-Dynamic Company, of Philadelphia, the initials of which title serve to form the title word of the system. The cars are being manufactured by the Brill Company, of Philadelphia, and will be lighted by electricity, equipped with the Edco system of motors and gearing, the gearing running in oil, with dust-tight covers for motors, and with a number of 23M type accumulators, designed to give an average speed of eight miles an hour and a maximum speed, when desired, of 15 miles an hour.

Cambridge.—The electric lighting of Cambridge is to be proceeded with at once, and contracts for the tenders recommended by the Corporation's adviser, Dr. Fleming, are to be prepared and submitted to the Council for their approval. Such is the result of the quarterly meeting of the Cambridge Town Council last week. The Electric Lighting Committee reported that various points in Dr. Fleming's report are receiving their careful consideration, but that they were not in a position to make a recommendation upon it. The Rev. Alderman Finch moved an amendment to the effect that the committee be instructed to prepare contracts. A discussion followed, in which the opinion was expressed that the estimates prepared were much overloaded. On the other hand, Councillor Young said that the most rosy view showed only 5 per cent., and Dr. Fleming had made no allowance for cost of land and of collection. They had gone to great expense to employ Dr. Fleming to advise them, and now the Council was asked to make a further estimate. Councillor Vintnor supported the amendment, as it was stated that the lighting was to be for the whole town, and whether they got a profit at first or not, he was sure in the near future they would do so. The amendment was carried, with the effect stated in our first sentence.

International Railway Congress.—The questions to be discussed by the International Railway Congress, to be held this year in St. Petersburg, have been announced. Amongst the large number which appertain to the direct working and control of railways, there appear several which are of importance to electrical engineers. Questions: (16) Fixed signals and the block system; (17) The lighting of signals; (18) Train signals, communication between carriages and locomotive; (37) Special forms of motive power, including electric railways; (40) Light railways as feeders, and the use of tramways or telpher lines as auxiliaries; methods adopted by the main lines to establish these feeders. We should also like to see the discussion of some more scientific method of fog signalling by electricity, as by the method recently commented on in these columns by Messrs. Andrews and Guy. The recent fogs in London must have cost thousands of pounds to the railway companies, and a method by which an indication of the signals could be given on a miniature semaphore on the engine, if practicable, should be brought forward before the congress and throughly discussed. The other questions have already received much attention from electricians and electrical engineers, and it needs no words upon our part to point out the desirability of bringing practical apparatus or designs before this important congress.

College Extension.—A meeting was held on Monday in support of the funds which are being raised for the extension of King's and University Colleges for laboratories and endowment. The Lord Mayor presided, and the Bishop of London moved the resolution that it is essential for the welfare of London that its university teaching should be maintained at the utmost efficiency. Mr. W. H. Preece, F.R.S., spoke in favour of the endowment of science, and regretted the largeness of London acted against the feeling of local interest which induced such men as Whitworth, Mason, Firth, or Owen to leave their wealth to education. It was the bounden duty of England to maintain its own amongst the war of competition by increased facilities of education. During the meeting it was announced that among the donations already given or promised are £6,000 from Lady Siemens for a "William Siemens Laboratory" of electrical engineering; boilers and engines from Messrs. Davey, Paxman, and Co.; £1,000 from the Clothworkers' Company, in addition to £225 a year devoted to exhibitions; about £1,100 from the Carpenters' Company; £1,000 from Lord Grimthorpe; £1,000 from Mr. W. H. Smith; and £250 from Prof. Banister Fletcher for an architectural museum. Another £4,000 is required for the electrical laboratory at King's College, and new electrical and mechanical laboratories are required for University College.

Croydon.—The question of overhead wires came before the Croydon County Council last week, when the town clerk reported that the Board of Trade propose to insert in the provisional order a clause to the effect that overhead wires shall not be erected without the consent of the Board of Trade. No such prohibition was contained in any provisional order granted to a local authority last session, and although it is probable that in all the principal streets, and perhaps throughout the borough, the Council would think it desirable to have underground wires, yet the committee consider the restriction undesirable, and appointed a deputation to wait upon the Board of Trade and remonstrate against its insertion. Councillor King asked why it was proposed to go to the Board of Trade and ask them to leave out the clause prohibiting overhead wires? It would be a serious thing if the town were lighted by electricity from overhead wires and then for the wires to break down, as they did in New York recently, throwing the whole city into confusion, and making the telephone and telegraph services absolutely useless if a fire had broken out. Councillor Goodwin said he viewed the introduction of overhead wires into Croydon with a great deal of apprehension, and hoped the committee would not be so unwise as to try to remove the restriction the Board of Trade had placed upon the matter. He moved an amendment to that for the adoption of the report to the effect that the paragraph be omitted from the report. The amendment was, however, lost by an overwhelming majority.

An Electrical Omnibus.—A sensation was created the other afternoon in some of the streets of the City, says the *Financial Times*, by the appearance of Mr. Radcliffe Ward's patent electrical omnibus. It was brought out for the satisfaction of a few shareholders of the small private company which has taken up the enterprise, and who occupied inside seats, their desire being to test its running with a view to the starting of a regular passenger traffic with such vehicles. Mr. Ward drove the car himself, the going being very easy, and sharp curves, such as that where Throgmorton-street joins Old Broad-street, were turned without any mishap. A few horses were startled, and cabbies and ordinary 'bus drivers seemed to regard the machine as an unwelcome monstrosity, judging from the volleys of derisive chaff with which they continually assailed it. One elderly worthy, in charge of a hansom, who evidently took our representative for the boss of the show, seemed, however, to think a tone of gentle admonition more effective, for, with a solemnity of manner, worthy of the elder Mr. Weller, he impressively asked, "Do you call this a proper sort of vehicle to take through the streets of London?" The rapidity of motion did not allow time for a reply, but our representative's conclusion was that if the electrical 'bus can always be as successfully worked as he saw it managed by Mr. Ward, it will be unobjectionable when the horses have got used to it. Mr. Ward declared the management easy, and said a 'bus of this nature can be run at a cost of 3d. a mile, whereas the working expenses of the General Omnibus Company are at the rate of 4¾d. a mile.

Colliery Lighting.—The installation of the electric light has been recently been fitted up at Messrs. Pease and Partners' Stanley Colliery, where Edison-Swan lamps of various sizes (from 16 c.p. to 200 c.p. each) are used. The machinery is fixed on the surface, and consists of a pair of Tangye high-speed coupled vertical engines, driving a 6,000-watt dynamo, by means of a 5in. leather link belt. Conveniently near the dynamo there is a neatly arranged switchboard with the main cut-outs, voltmeter, etc., and from this are led off three main circuits. Of these—the first supplies current to the screens and travelling belts, where the coal is picked over by hand; the second lights the pitheap and two seams underground; the third lights the offices, workshops, and yard. The screens and belts are lighted by pendant lamps of 16 c.p. each, fitted with strong white enamelled iron reflectors, by means of which all the light is cast down on to the coal. On the pitheap and round the shaft bottom in each seam 50-c.p. lamps are used, and these are enclosed in strong galvanised iron wire guards, which save the lamps from being broken by an accidental blow. In the yard in front of the workshops there is fixed a 200-c.p. lamp, enclosed in a strong weather-proof, enamelled iron fitting, with an outer globe of clear glass; and on the gangway two 100-c.p. lamps, in similar fittings, are now being erected. The stables, joiner's shop, smith's shop, etc., are all lighted by 16-c.p. or 25-c.p. lamps, either protected by wire guards or fitted with enamelled shades, as was found most suitable. This plant has now been running some little time, and, we believe, is giving every satisfaction. The contractors for the whole of the work were Messrs. Barnett, Barnard, and Co., of Newcastle-on-Tyne, who have lately taken over the Newcastle branch business of Messrs. Sydney F. Walker and Co.

Barnsley.—The electric lighting question at Barnsley is still unsettled, and there is the same state of indecision and absence of definite plan that has unfortunately characterised several important schemes of public lighting. At the meeting of the Barnsley Town Council on Tuesday, correspondence between the committee, the Board of Trade, and the Westinghouse Company was submitted. It was to the effect that the Board of Trade withdrew their sanction, and asked the Corporation to supply underground mains instead of overhead, on the score of safety. The town clerk pointed out that this would mean £20,000 extra cost on the town, that consent to borrow £23,000 had already been obtained, that a provisional contract had been entered into for Westinghouse plant, and that if underground mains were insisted on the town would not be lighted. The Board of Trade, in view of these facts, replied they would not absolutely refuse, but "hope the Corporation will bear in mind the desirability of placing the electric lines underground, and will take the necessary steps to do so if the opportunity should arise." The correspondence with the Westinghouse Electric Company simply amounted to the company throwing up their contract, and the committee recommend "that no further negotiations be entered upon with that company, and they defer the issue of advertisements for other tenders for consideration at next meeting." Alderman Blackburn moved the adoption of the minutes, and said they must before going further into the question have information what course the Board of Trade would take in the future, as if the underground wires were insisted upon the Barnsley Electric Lighting Act would remain unexecuted. Mr. Wray said that if overhead wires were approved they should go on. The whole question was yet for the committee to consider and report. The minutes were then adopted.

St. Pancras.—St. Pancras Vestry, which alone of London local authorities has decided to undertake electric lighting, incurring an initial expense of £50,000, is proceeding expeditiously with the execution of the necessary works. The Electricity Committee, reporting to the Vestry meeting on Wednesday, stated that the Stanhope-street station was approaching completion, and the mains first to be laid would be forthwith laid along Tottenham-court-road and Hampstead-road, and along Euston-road from Euston-square to Cleveland-street. The mains would be for both arc lights and incandescent lights. Alderman Gibb, vestry clerk, reported with respect to the Electrical Exhibition to be opened at the Vestry Hall, Camden Town, on Monday, the 16th proximo, that there would be 35 exhibitors, and it was doubtful whether all applicants could be accommodated with space. Mr. Preece, chief electrician of the General Post Office, would in all probability take an active interest in the exhibition, which would be open for a week, a small charge being made for admission, and this, with the payments for space, would, it was believed, cover the necessary expense—no recourse being had to the rates for the purposes of the show. Among the intending exhibitors are: Willans and Robinson, the Electrical Construction Corporation, Gill and Co., Edison-Swan Company, Benham and Froud, Strode and Co., Rashleigh, Phipps, and Dawson, Clark, Muirhead, and Co., Johnson and Phillips, and Woodhouse and Rawson. The Electricity Committee had appointed an exhibition sub-committee to confer and act with the Exhibitors' Committee, and the intended exhibitors had taken up the project in so earnest and energetic a manner that there seemed to be but little doubt that the exhibition would be in every sense a success. A further report of the Electricity Committee stated that the Vestry were allowed to charge per unit for the electric current the sum of 8d. The actual cost, the committee expected, would not exceed 4½d. They thought the price charged should for the present be less than that charged by the companies, but should at the same time secure a profit to the Vestry. Hence they recommended that the charge be 6d. per unit, but that for the present no minimum charge be fixed. The reports were unanimously adopted.

UNDERGROUND MAINS.—IV.

THE CALLENDER SOLID SYSTEM.

(Concluded from page 183.)

The accessible junction-boxes are fitted with an indiarubber gasket round the joint of cover, and are screwed down with a phosphor bronze set-screw.

The buried junction-boxes are used under roadways, and are covered with the ordinary pavement without cover plate, the paving being lifted if it becomes necessary to examine the connections, in which case the bitumen can be easily removed by the use of a heated tool.

Ordinary sizes of cables are: for feeders $^{91}/_{11}$, equalling one square inch sectional area, $^{61}/_{11}$, equalling $\frac{6}{10}$in. sectional area of copper, and both can be laid up to 250 yards length; for heavy feeders $^{91}/_{9}$, equalling $1\frac{1}{2}$in. sectional area, laid in 150-yard lengths. The distributors are usually $^{37}/_{13}$ cable, $\frac{1}{4}$in. sectional area, or $^{19}/_{14}$, $\frac{1}{10}$in. sectional area, laid, according to circumstances, up to 600 or 700 yards. The latter size is usually employed for the house service lines.

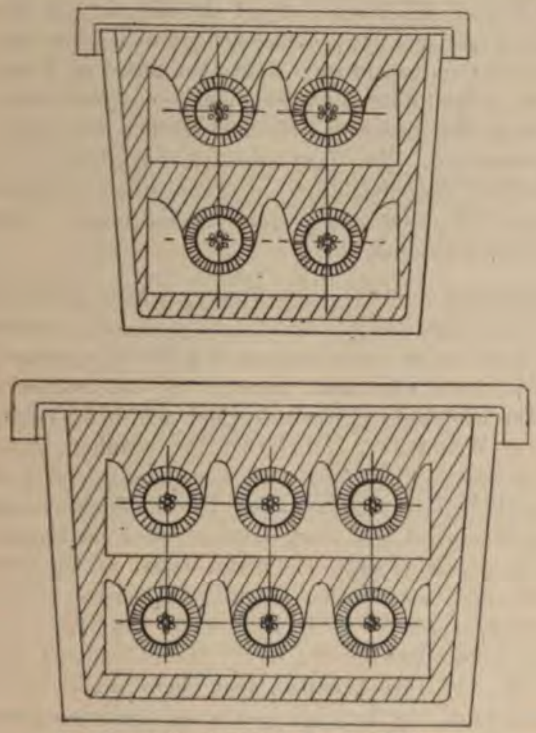

FIG. 7.—Callender High Tension Cables.

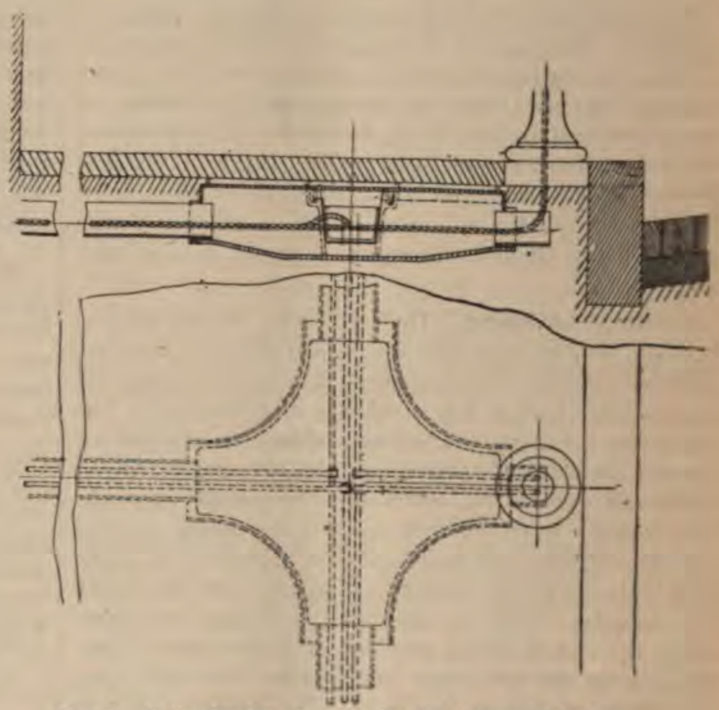

FIG. 8.—Callender Junction Box for Arc Lamps in Series.

The Callender solid system is particularly applicable to high-tension systems for arc lighting in series where the mains have to be led from lamp to lamp under the streets, and the strength of current remains constant, without necessitating increase of cable section even if the number of lamps is increased.

Sections of mains for high tension are shown in Fig. 7, where the sizes of troughs for four and for six highly-insulated $^{7}/_{16}$ cables are given. The process of laying is exactly the same as that previously described, with the exception that the troughs are always covered with a cast-iron cover, or in particular places with steel covers, to afford absolute security against accidental interference by picks of other workmen.

The method of connection of the arc lampposts in series is seen in section and plan in Fig. 8, where a junction-box at a street corner is shown. The cables are laid in the trough with sufficient spare length to go up the lamppost without joint, a junction-box being let in under the pavement and covered with a steel plate lid. These high-tension mains can be easily laid in lengths up to one mile without joint.

The following is a fairly comprehensive list of central stations at which the Callender and Callender-Webber mains have been laid down:

Chelsea..................	The Chelsea Company. Draycott-place station, Clabon-mews station, complete set of feeders and distributors.
South Kensington...	Ditto. Egerton-gardens central station. Ditto.
Whitehall	Metropolitan Company. At Charing Cross.
Strand	Electricity Supply Company (late Gatti). Bull Inn-court station, and along the Strand, Charing Cross district.
Liverpool.........	Liverpool Electric Company. Three stations, comprising the complete district between Lime-street and the Docks.
Birmingham	Birmingham Company. All the central portion of the city.
Bath	Mr. Massingham. Arcs for the town lighting. Incandescent supply for private lighting.
Brighton	Network for Corporation plant.
Le Mans, France ...	Central station network.
St. Austell	Central station for private supply.
Victoria Station......	Edison and Swan Company. Installation for the railway station.
Law Courts............	Crompton. Law Courts building.
Temple..................	Edison-Swan Company. House lighting in the Temple.
Westminster	Westminster Company. Many miles of C.-W. casing laid in conjunction with Crompton mains where culverts were unsuitable.
Northampton	Crompton and Co. Several lengths of main, laid both on C.-W. and solid system, in conjunction with Crompton culverts.

In addition to which are a large number of mains for isolated installations, amongst which are: Buckingham Palace (Her Majesty Queen Victoria), Hatfield House (Lord Salisbury), Normanhurst (Lord Brassey), and many others.

ELECTRIC TRACTION.

I.—THE ELECTROMOTOR.

Although the successful employment of electricity as a mode of energy in the *transmission of power over a distance* has been known for more than 50 years, it only reached a practical and efficient outcome when Siemens and Gramme devised their world-known improvements in dynamo generators, and when the Gramme machine, some time after it was brought out, was shown to be reversible—that is, could be employed almost equally well as a motor yielding mechanical energy, or as a generator yielding electrical energy.

Before, however, enquiring even generally into the uses of electric motors for the transmission of power, it may be advisable to clear the ground in some degree by defining, more or less accurately, the leading phrases or terms to be employed in considering the entire system. The word "dynamo," for instance, had for a long time the meaning of "electric generator" simply, being thereby opposed somewhat to the term "motor"; but as a rule it is nowadays held to include both generator and motor.

To define these terms more narrowly, we may say that an electric generator is an appliance in which mechanical energy is used to obtain electrical energy, whilst an electric motor, being the converse of this, is an appliance supplied with and utilising electrical energy for conversion or transformation into mechanical energy.

Speaking now in more concrete fashion, we have, in the case of a generator, the engine, turbine, windmill, or other prime mover, which drives the generator by means of shafting, belts, or any other such gear. The generator, being thus mechanically actuated, can be made to yield currents of electric energy capable of being carried along suitable intermediaries over any distance, and often utilised to give light, heat, or power.

In the case of a motor, the energy supplied to it is in the shape of electric currents, and from certain reactions which thereby take place in the motor, an actual mechanical motion is required on the spindle, such as is required to drive machinery of any kind.

Although a distinction has herein been drawn between "motor" and "generator," it need not be thought that any essential difference of principle exists; the two appliances may be of identically the same design. The difference lies in the manner according to which they are used. Take any dynamo, and drive it by means of a belt from an engine, electrical energy may be obtained as a result from the machine, which accordingly is said to be a generator. Take the same dynamo, and allow to pass through it a current of electrical energy from some outside source, under certain restrictions the dynamo will run as a motor, yielding mechanical energy, and if the electric current supplied to the motor from outside be sufficiently powerful, the motor might even—if still connected to it by the belt—drive the engine or other prime mover, thus completely reversing the previous order of things.

In other words, dynamos are reversible in action: drive them mechanically, and they yield electric energy; pass a current through them, and they rotate so as to give mechanical power and motion.

So far, generator and motor have been regarded apart from one another as individual and separate appliances, but it is of course evident that they can and must be used in combination. That is, in order to use a motor, we must also have somewhere a generator of large capacity for obtaining the necessary supply of electric energy.

The great principle of conservation of energy is seldom better seen than in this instance, and users of electric motors will do well to bear that principle constantly in mind.

We start with a given amount of energy in our prime mover, and lose some of it, to begin with, in engine belts or shafting, besides which, our electric generator is not altogether perfect. Probably, out of the electric generator we may obtain in the shape of electrical energy about 80 to 90 per cent. of the mechanical energy given off at the engine flywheel. Before using this electrical energy for purposes of light, heat, or power, it needs to be conveyed from the generator to the place where it is required, and there ensues a slight loss in this transference of electrical energy, although the means of conveyance (in the shape of metallic wires) are the best and most adaptable that can be devised.

Then there is a fourth loss in the electric motor, wherein takes place the transformation of electrical into mechanical energy, and a final amount—though small in quantity—is lost in the means adopted for employing the mechanical energy thus obtained, such as belts, and other gear.

There are accordingly five directions in which loss or waste (as regards the original energy) may take place, and these can be shown in the following manner:

1. From flywheel to generator, or loss by transmission.
2. In the generator itself, or loss by transformation.
3. From the generator to motor, or loss by transmission.
4. In the motor itself, or loss by transformation.
5. From the motor to machines requiring to be driven, or loss by transmission.

Now attention has been directed to these points—which may perhaps cause the electric transmission of power to appear on the surface anything but advantageous—for the special reason that the losses of energy thus incurred at each step *are extremely small and unimportant* when comparison is made with other methods of employing power at a distance.

This statement is made more especially with regard to long-distance transmission of power—such as would be involved nearly always in the various systems of electric traction, the subject with which we are now most concerned, rather than short-distance transmission; but there are many cases where it is profitable to use electric motors even a few feet away from the prime mover and electric generator. These instances, indeed, will be found on examination to constitute the "rule," and by no means the "exception."

"The difficulties of all systems of transmission increase with the distance, but for electricity not so much so as for mechanical means, and consequently the advantages of electric transmission become more apparent at long distances."

It is more particularly with such long-distance transmission that electric traction has to deal.

Other systems of transmitting power include the use of such methods as shafting, cotton ropes, and other forms of belting, steam, compressed air, water at high pressure, and wire ropes; and as regards all of these it may fairly be claimed that electricity is enabled to show convincing proofs of its great superiority, taking all points into consideration.

"How easily, and how quickly, and with little occasion for repairs, can two flexible cables be laid, in almost any position, for mines, iron works, docks, factories, as compared with shafting, ropes, steam-pipes, compressed air."

In deciding upon any one system of transmission of power the ultimate appeal must inevitably be made to *cost*—that is, first, the capital outlay, and second, working expenses.

On both these points electricity excels any of the systems named, wire rope transmission alone being in the least a competitor in lowness of first cost for distances up to, say, three miles. As for efficiency and economy in cost of operation, electric motors have at the outset a considerable advantage in consuming power in strict proportion to the work done, so that no energy is wasted.

The motor absorbs from the generator just as much energy as it requires to do the work that is given to it, plus a small quantity to overcome friction, etc., and the generator in turn calls on the engine by means of the belt for a corresponding amount of energy. The absorbed power is therefore exactly proportional to the work that is being done. "Electric motors help themselves, as it were, to only such an amount of energy as will enable them to deal with the work imposed on them."

Returning now for brief reference to the losses enumerated in the complete transmission from prime mover to machine moved, it should be pointed out that the first one—that which takes place between the flywheel of prime mover and pulley of generator—will be found in practice common to all systems of transmission over a distance. The next one, loss in the generator itself, is very small; it is a poor dynamo which will not give an efficiency of 90 per cent. of the energy put into it.

From the generator to the motor—along the conductors, or intermediary wires, through which pass the currents of electric energy—there is another loss, but one that with careful designs and good workmanship should prove less in comparison than with such methods as compressed air, steam, gas, or water.

Copper wires are always more easily managed and erected than iron pipes, besides which the prime cost is usually less.

In the electric motor, again, there should be as great an efficiency as in the generator, and, indeed, it would be somewhat difficult to name many energy-transforming machines or appliances which return so much of the energy put into them. The generator and motor in combination can, as a rule, be depended on for an efficiency of 80 per cent.

The loss between motor and machines or appliances to be driven is purely the mechanical one of belting or gear friction, and can be got rid of at once by the simple expedient of coupling the motor spindle direct to that of the machine to be driven.

As a rule, it is not desirable to reduce the speed of electric motors too greatly; in many cases the faster they run the more efficient they become; and if, therefore, high-speed machines are to be driven, the motors are coupled direct to them so as to increase their electrical efficiency, and at the same time avoid the loss of transferring their mechanical energy through the medium of belts or other gear.

Although, therefore, it might be thought that the transmission of power by electricity cannot possibly prove so economical as, for instance, a system of wire rope transmission, because the former has no less than five conceivable sources of loss between the prime mover and the machine to be moved, whereas the loss of energy in the case of a wire rope is confined simply to that involved by the friction, etc., of a long and constantly travelling endless rope, with the necessary pulleys and wheels for it to run upon; yet when it is remembered that the loss in the latter case (except for quite short distances) may reach as great an amount as 60 per cent. or more, whereas the total loss on all the five points mentioned in connection with electric transmission should not exceed 35 per cent. at the utmost, it will be seen at once that owing to high efficiencies at each conversion, the more roundabout method is, after all, more economical—the "longest way round is the shortest road home."

(To be continued.)

CANTOR LECTURES.

Mr. Kapp requests us to publish the following copy of a letter addressed to the General Electric Power and Traction Company, having reference to these lectures.

[COPY.]

Messrs. The Electric Traction and Power Company, Limited,
Maldon-crescent, Prince of Wales-road, Kentish Town.

Dear Sirs,—I was surprised to hear last night from Mr. Snell that he considers the figures I gave in my Cantor lecture with reference to the Barking-road tramway incorrect. When towards the end of last year I applied to Mr. Frazer for information about the working of battery cars, I was under the impression that this gentleman was the member of your company who had the entire control of your traction work, and I therefore took the figures which he gave me as authentic and correct. If, however, as Mr. Snell asserted last night, the figures are not correct, it appears desirable that the necessary corrections should be made in the tables I gave at the Society of Arts lecture; and I shall do this if you will kindly supply me with the exact figures.—Yours faithfully,

Erba, Wimbledon, GISBERT KAPP.
February 20, 1891.

The secretary of the company also requests us to publish the following letters.

[COPY.]

Gisbert Kapp, Esq., Feb. 20th, 1891.

Re Cantor Lectures on Monday, 16th inst.

Dear Sir,—I am requested by the managing director to draw your attention to the enclosed printed matter with reference to data relating to the Barking-road electric installation, which is the property of the General Electric Power and Traction Company, Limited. The figures thus given are entirely misleading, and the publication of them is calculated to seriously injure our interests as well as those of the North Metropolitan Tramways Company, and we must request you accordingly to withdraw the Tables 4 and 5, and the statements made by you based thereon at the Cantor lecture, in such a public manner as will be likely to reach all persons before whom the original tables and statements have come.

If the statements have been based upon information obtained from Mr. Frazer, we may call attention to the fact that he left the company's employ in July last, and has since had no opportunity of acquiring any knowledge as to the improvements that have taken place since then, which renders the data published by you still further misleading.

In the event of your failing to comply with our request, we shall, in the interest of our shareholders, be compelled to consult our solicitors on the subject.—Yours faithfully,

(Signed) W. G. M. MACKENZIE, secretary.

[COPY.]

31, Parliament-street, S.W.,
February 21st, 1891.

The General Electric Power and Traction Company,
Limited, 35, New Broad-street, E.C.

Dear Sirs,—In reply to your letter of yesterday, the statements to which you object were based on figures obtained from Mr. Frazer, and were given at the Society of Arts distinctly on his authority, and not on mine. After your explanation, which puts a totally new complexion upon the matter, I am, of course, myself most desirous to withdraw from my lecture any statement or table the accuracy of which is questioned, and I shall on Monday withdraw the two Tables 4 and 5, and statements connected with them. At the same time allow me to point out that in your interest as well as in mine withdrawal alone would not be so effective as withdrawal combined with the substitution of the correct figures, and I shall feel obliged if, on Monday, you would send me a telegram authorising me to state that when the lectures appear in print, the obsolete figures of Mr. Frazer will be replaced by figures corrected up to date and supplied by you.—Yours faithfully,

(Signed) GISBERT KAPP.

NEW THOMSON-HOUSTON SLOW-SPEED RAILWAY MOTOR.

We illustrate on this page a new motor which the Thomson-Houston Electric Company has been at work upon for some time, and with two of which a car on the West End road in Boston has recently been equipped. It has been named, from its construction, the "single reduction gear" motor, but is ordinarily called the "S.R.G." As will be seen in Fig. 1, the motor is very nearly iron clad, having two pole-pieces of ample surface, and carrying two field coils, which partially surround the armature core. The magnetic circuit is completed on the front end of the motor through the face plate and at the back through the frame on which are cast the axle-boxes and arms which serve as a support for the armature shaft bearings. The armature is of the Gramme ring type, and the bobbins are wound close together around the entire rim, Fig. 2. One great advantage of this construction is the fact that any coil can be easily rewound without disturbing its fellows, while with the drum armature in the type of motor formerly used by the company the winding all had to be renewed down to the injured coil.

The brushes are placed exactly opposite and in a horizontal fixed position. There seems to be no sparking under the ordinary running conditions, and the brushes are easy of access.

The field spools are protected on all sides by the fields and frame. The gears are entirely enclosed in a dust and oil-tight case, which is provided with a hand-hole closed by a spring cover, permitting ready examination of gears and the introduction of lubricants.

A sheet-iron pan extending above the centre of the armature shaft entirely encloses the bottom and sides of the motor and protects the armature and commutator from dust, snow, and water. The advantage of this casing was strikingly demonstrated during the recent snow storms, the "S.R.G." coming through unharmed, while some of the fields on the old style of motor came to grief from the effects of excessive moisture. This pan has a sliding bottom, and is attached to the motor in such a manner as to permit of being readily removed for access to the various parts.

The motor when mounted on a truck with 30in. wheels is designed to clear the tops of the rails 4in. The spur gear on the armature shaft is of steel, 4½in. face, and has

14 teeth. The split gear on the car axle is of cast iron, with the same width of face, and has 67 teeth. The speed of the armature shaft relative to that of the car axle is nearly as 4·8 to 1; when the car is running 10 miles per hour the armature makes 538 revolutions per minute, or the speed of the armature is 53·8 turns per minute when the car speed is one mile per hour. The gears are surrounded by an iron box so that they may be run in oil.

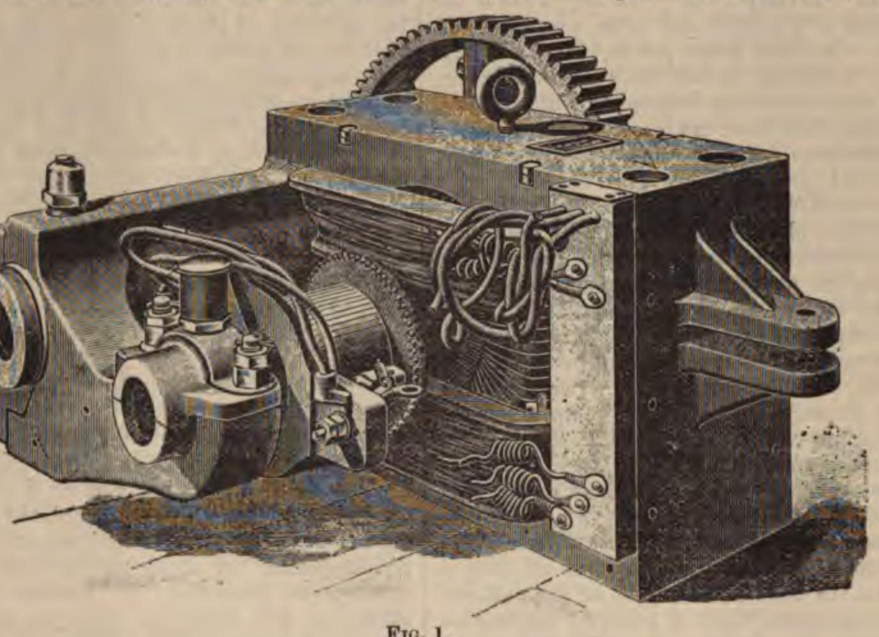

Fig. 1.

The facility with which the armature can be removed simply by lifting the upper field, the ease with which an armature bobbin can be rewound, less liability to damage from centrifugal action, such as bursting of binding wires, displacement of coils, breaking of commutator connections, all ensure a minimum amount of expenditure for repairs.

The accompanying illustrations show very plainly the general appearance and detailed construction of the motor.

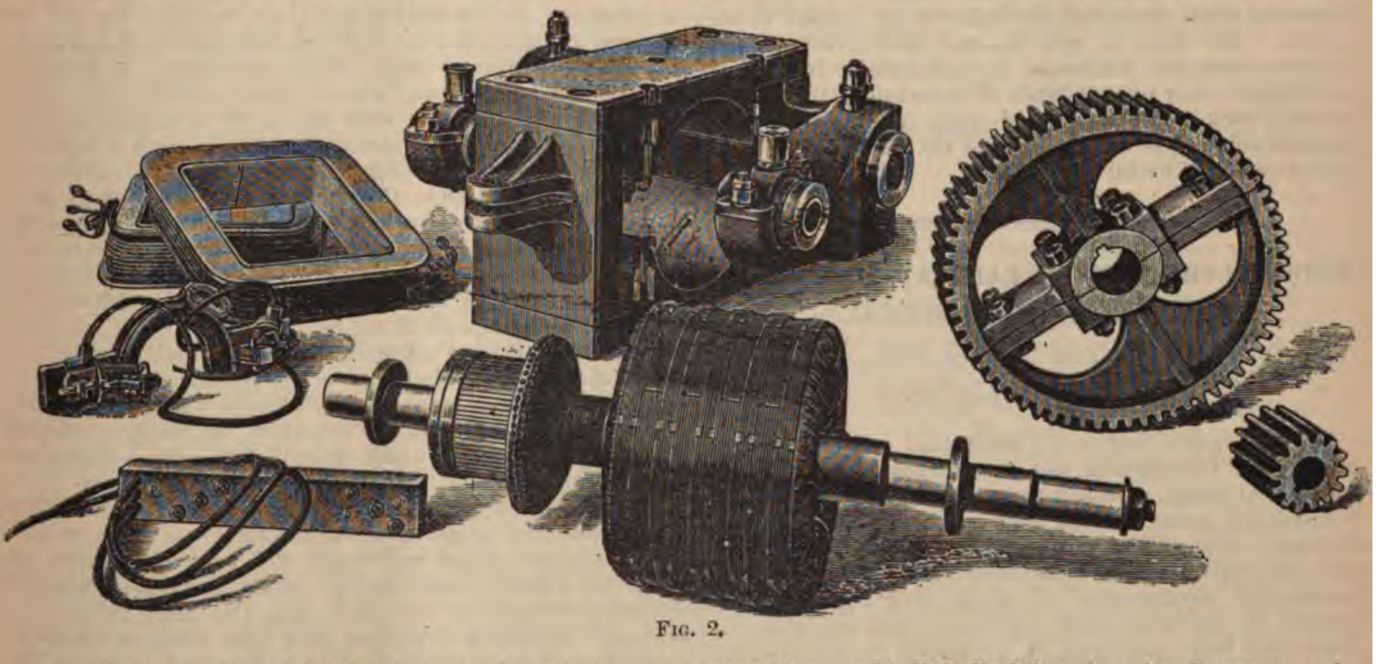

Fig. 2.

The advantages claimed by the designers have been summarised as follows:

1. Noiseless single reduction gears, protected from dust and run in oil, and noiseless commutator. 2. Electrical and mechanical simplicity attained by use of two-pole type of motor. 3. Slow speed and powerful torque obtained by proper proportions. 4. Protection for fields and armature from dust and water. 5. Accessibility to all parts. 6. A ring armature not likely to become damaged, and, if accidentally injured, permitting easy repairs. 7. Moderate weight. 8. Reasonable cost. 9. Commercial efficiency. 10. Small maintenance expense.

LITERATURE.

"The Law and Practice Relating to Letters Patent for Inventions." By Robert Frost, B.Sc., F.C.S., Barrister-at-Law. Stevens and Haynes, Bell-yard, E.C.

There are various ways of writing law books now in vogue. A man may simply go through all the decided cases, and making a short abstract of each set this down as it stands, arranging the cases subsequently according to subject-matter: as, for instance, is done by Mr. Clement Higgins in his useful Digest of Patent Cases, or he may go a step further and weave these cases into a connected argument, as in Benjamin's Sale of Goods, or Lindley's Partnership; or again he may write a legal treatise on the whole subject, founded upon a careful study of all the cases, and citing them as his authority for each successive proposition: as Sir F. Pollock has done for Contracts, and Torts, and Mr. Joshua Williams for Real and Personal Property.

A fourth course is open when the law on the subject is contained in statute; which is to take the principal statute as a backbone and attach to it a continuous commentary, citing the cases in the notes on the various sections, as Mr. Lawson has done excellently for patents. The law on patents, however, is not to be found in statutes, except so far as procedure and the legal effect of the necessary steps and preliminaries are concerned. Mr. R. Frost, therefore, has done well, in our judgment, to adopt the third of the processes we have indicated when writing his new book on "Patent Law and Practice." For it is not to statutes, but to the cases "tried and determined by and according to the common laws of this realm," under the second section of the old Statute of Monopolies of 1623, that we must look for the law that is material for our guidance on the questions most frequently raised in the courts in patent cases. Such questions, for instance, as the meaning of "true and first inventor," or of "novelty" and "utility," what is the proper subject-matter of a patent, and what constitutes an infringement of it. On these moot points, Mr. Frost has done well to cite verbatim, rather than to summarise, passages from the most important judgments, both old and recent. And he appears to have made a judicious selection of them, adding references to other cases when necessary. Practice, however, and procedure are part of Mr. Frost's subject, and he has dealt with them not only in his text, but also by the addition of an exceedingly bulky appendix. The latter contains, besides the statutes, rules, and foreign conventions relating to patents, almost every form and precedent that the author could lay his hands upon, whether issued by authority or required in drafting, many of which are and some may be found useful for reference. This large appendix, which forms nearly a third of the whole book, would appear to be intended mainly for the use of any patent agents who are out of reach of the Patent Office; the multifarious forms are certainly of little use to the legal profession. Both in these forms and in the text of his work the author betrays many marks of a "'prentice hand." Small slips in form as well as a want of familiarity with general law, of which patent law, is after all, only a branch, indicate that the book is the result of the author's industry and research, rather than of his own experience and matured opinion. For instance, besides avoiding the numerous trifling inaccuracies which Mr. Frost has inserted, a lawyer would hardly think it necessary to set out a number of cases to show that where there is no fear of a defendant continuing to infringe a patent, the Court will not grant an injunction against him.

It used to be a common saying that there were only three ways of getting on at the Bar—marrying a good solicitor's daughter, writing a good book, and a miracle. The writer of this book is to be commended for trying the second of these ways, and he deserves to succeed in his object. His book is well planned and arranged, and contains abundant references to authorities. It does not add much to our present stock of knowledge, but it is yet a useful book of reference; and when improved for subsequent editions, as will no doubt be the case, may develop into a good and useful law book.

NOTES ON THE ELECTRIC RAILWAY: HISTORICAL, STATISTICAL, AND TECHNICAL.*

BY FRANKLIN LEONARD POPE.

(Continued from page 187.)

The principle of converting mechanical energy into electricity and reconverting this by a reversed dynamo into mechanical power, naturally suggested the practicability of transmitting power through electric wires to any required distance. One of the earliest results of this conception was the revival of the electrically operated railway, the commercial development of which had necessarily remained in abeyance until machinery was available for furnishing large quantities of electricity at a moderate cost.

One fact of controlling importance in this connection is that electricity is capable of being supplied to a moving motor through a frictional or rolling contact, a method of communicating mechanical power impossible of realisation by any other known means. Hence the possibility of supplying a power by machinery situated at any required distance from the moving train by extending the conductor to and along the railway.

The credit of priority in the invention of the electric railway in its modern form—that is to say, the moving electromotor on the car connected by electric conductors with a stationary dynamo—I believe to be justly due to Stephen D. Field, now of Stockbridge, Mass., who was living in San Francisco in 1877. This was about the time of the introduction of the cable system of street railways, which was resorted to in San Francisco, for the reason that some of the grades were so excessive that the use of horse power was absolutely out of the question. Observing the operation of the cable road, it at once occurred to Field that electric power might be applied to the same purpose with as great or even greater advantage. At that time no dynamo-electric machines suitable for this purpose were to be had in the United States, and he accordingly ordered one from Europe for experimental purposes. It took a long time to make it, but at last it was completed and shipped to San Francisco by a sailing vessel. The vessel was wrecked on the voyage, and the machine went to the bottom of the sea. Not yet discouraged, he ordered another one, which eventually reached him in good order, and enabled him to commence his long-delayed experiments. He tried first an electric elevator, in which he was successful. In 1879, having exhausted his resources, he came to New York, bringing with him his plans, with which he hoped to enlist capital to continue his work. He laid these plans before me, and being impressed with the entire practicability of his scheme, I gave him every encouragement in my power. The plan which he had devised contemplated the enclosing of the conducting wire in a conduit beneath the street. He was not successful in obtaining sufficient means to properly develop his invention; he became involved in tedious, harassing, and expensive litigation with wealthy corporations, and his health failed him at a critical time, so that for years he was incapacitated from active work; but the single railway which is in operation in this country to-day, and embodies his matured conceptions, is regarded by competent judges as in many respects superior to any yet brought before the public. Field's electric locomotive was first exhibited at the exhibition of railway appliances in Chicago in 1883, during the continuance of which 27,000 passengers were transported by it.

In the summer of 1882, Dr. Joseph R. Finney exhibited in Allegheny, Pa., an electric street car, for which the current was supplied by a copper wire, about the thickness of a lead pencil, 15ft. or 20ft. above the street. A small trolley fitted with grooved wheels, running on this wire as on a track, and connected with the car by a flexible conducting cord, served to convey the electric current from the suspended conductor to the motor. Some of the earliest of the successful lines in this country were arranged upon this plan. At a later date this was superseded by the type of contact wheel now in general use, which runs underneath the wire and is mounted upon the end of a long yielding rod bearing a certain resemblance to a fish-pole supported upon the roof of the car.

I have said that the original invention of Field contemplated the supply of electricity to the travelling car from conductors enclosed in a conduit beneath the pavement. He, as well as many other inventors, appreciating the force of that prejudice which undoubtedly exists—among newspaper editors—against any avoidable multiplication of overhead electric wires in the streets, realised that the great prize to be sought for above all others was the invention of a system of electrical supply which should dispense altogether with the overhead line. Hosts of inventors have diligently wrought for 10 years upon this most difficult problem. Hundreds of patents have been taken out, and more than a million dollars have been disbursed in paying for tuition in the costly school of experience. More than once, and in more than one direction, success has at times seemed almost certain, yet truth compels me to say that from the hard practical standpoint of dollars and cents, by which every invention must first or last be tried, the net outcome of all this vast expenditure of labour, time, and money has up to the present moment been almost insignificant. The reward which awaits the fortunate person who succeeds in completely solving this problem may well be regarded as a potentiality of wealth beyond the dreams of avarice.

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* Paper read before the New York Electric Club, Jan. 22.

The problem of the underground conduit does not at first sight appear to be a very difficult one. It renders necessary, in the first place, a construction which will effectually resist the action of forces tending to disturb the condition of the wires, and with the heavy traffic on the streets this involves a very strong structure. It is absolutely necessary that the conductors shall remain insulated from each other and from the ground, under all conditions of weather. The exigencies of heavy rains and snows necessitate a construction which shall permit of a thorough insulation of the conductors and a drainage of the entire system. There are other minor points which require to be taken into consideration. Without going into details, it is sufficient to say that the conduit system has been tried on an extensive scale in Denver, Cleveland, and Boston, and to a lesser extent in several other places, but in every case the continual interference and interruptions consequent upon its use have exhausted the patience of the travelling public and compelled its abandonment. I do not wish for one moment to convey the impression that the problem is an insoluble one. My attitude is rather that which was taken by Prof. Tyndall some 10 years ago upon the question of the practicability of domestic electric lighting by incandescence. He had no doubt that the problem would be solved, but it was a great satisfaction to him to know that it would have to be done by somebody other than himself. I may, perhaps, say that I think great progress has been made in this direction within the past year, and I cannot but feel that the disappearance of the overhead system from the streets of all our larger cities and towns is only a question of time, although the objections which have been most strenuously made to its introduction are for the most part rather of a sentimental than of a practical character.

The storage battery system, both from the standpoint of the public and of the street car manager, is an ideal solution of the problem of electrical transportation. It has many features which especially commend it for city work. Each car is an independent unit, and hence no accident can materially cripple a well-organised system. The idea of being able to store a large quantity of electricity in a box under the seats of a car, to carry it around, and to draw from it a large amount of power, as required, is a most attractive one. Storage battery cars can be introduced in the existing systems, one car at a time. In cases of emergency they can be run over almost any route where a horse car can be run, not being restricted to the route of an electric conductor, and under ordinary circumstances the car can be run just as rapidly and controlled just as effectively as it can be with the trolley system.

All these advantages were recognised at an early day, and hardly had the storage battery been invented before it was applied to street car propulsion. The first storage car was operated in Paris, in 1882. The system was put in practical service on one of the lines in Brussels, Belgium, and continued for two years. It was also introduced in 1886, on the Madison-avenue line in New York City, and has been in operation there ever since. The results of the 10 cars now running on the Madison-avenue line appear to have demonstrated that the system may, with careful management, be made thoroughly reliable. Each car will carry a full load on a straight and level track 15 miles per hour, and will ascend grades not exceeding 5 per cent. and not more than 500ft. long at five miles per hour. A run of 40 miles can be made on a level track, which is considered a half day's work, with one charge of battery. The time required to replace the exhausted batteries with fresh ones is not more than two minutes.

There are, however, two serious objections to this system which have thus far been sufficient to prevent its adoption in other than exceptional cases. One of these is the great weight of the batteries, and the other is the lack of reserve power in the emergencies which sometimes occur. In other words, two considerations enter into the question, one of economy and the other of efficiency. To take up the question of comparative efficiency first, a very little consideration of the matter will show that the progress of the art, so far as yet developed, practically limits the use of storage battery cars to lines having very light grades—not more than 5 per cent. at the outside. Very many of our eastern cities—for instance, Springfield, Providence, Worcester, Albany, Troy, and many others which I might mention—have very severe grades, from 7 to 10 per cent., and some of them half a mile long. To start a heavily-loaded car in bad weather on such a grade as this means an expenditure for a few seconds of from 50 h.p. to 80 h.p. Experience has shown that this is far too heavy a tax upon the powers of a storage battery. Even on comparatively level lines, in our northern climates, the occurrence of a heavy storm of snow or sleet necessitates the expenditure of an abnormal amount of power, and it is on just such occasions as these when everybody wants to ride, so that the cars are loaded to their utmost capacity, and great dissatisfaction prevails if there is any delay or any lack of sufficient accommodation. It is at such times as this that the advantages of a distribution from a central station are most apparent. The whole number of cars, or extra ones, if necessary, can be run, and any amount of power required to force them through obstructions and to keep them running on schedule time can be supplied from the power station. It is merely a question of burning more coal.

Considering the economical aspect of the question, first, as to the original cost, it may be said roughly, the difference between the storage and overhead line system is not very great. The whole outfit, exclusive of roadbed, track, and building, for either system, will aggregate perhaps 10,000dols. per car. Now, as to the cost of maintenance and operation:

A 16ft. car with two motors, such as are most commonly used, will weigh 8,000lb., of which 4,000 is electric apparatus.

A storage battery car of the same size and capacity weighs 14,000lb., of which 3,800 is battery.

A full load may be estimated at 30 passengers, weighing about 4,000lb.

It will be seen that the storage battery car weighs nearly as much as two ordinary electric cars. It seems at present impracticable to operate a car with less than 3,800lb. weight of battery, and unless great improvements are made there is little reason to hope that this weight can be materially reduced.

(To be continued.)

BRISTOL.

The Town Council is in earnest now, as far as can be gathered from the proceedings at their regular meetings, on the subject of lighting the city by arc lamps, and of supplying private consumers in either arc or incandescent form. From a tentative scheme which had for its projected area only the four principal streets converging at the Council House, the proposal has grown to such dimensions as will practically include the entire route from the railway depot into Clifton, and will involve the employment of a couple of hundred or so of arcs in the main thoroughfares alone. It is satisfactory that the Council contemplates furnishing light and power at economical rates, and that it will endeavour to retain the control in its own hands, and to execute the works entirely with its own staff, augmented merely by such professional assistance as Mr. Preece, who is advising that body, may recommend. The example of the city of Bath has not been lost upon Bristol, and now that this incentive to action is being felt the hope is freely expressed that from the vast amount of detail the committee have gathered in the course of their visits to other provincial towns and to the metropolis, the Bristol installation will rank second to none for excellence. Many suggestions have been made with regard to the utilisation of the uncommon tide in the River Avon as a motive power, and it is only natural that with a rise and fall so great as 35ft. attention should have been drawn to this source of supply. The point to be attained, of course, is concentration upon some advantageous principle. The force is there, undoubtedly, if it can be brought to a head. Higher up the river, at no great distance, there are also some falls which might be used. In the Far East they grind corn by anchoring a boat in midstream, to which are fitted paddles after the manner of a steamer, the wheels revolving in the current and actuating a set of stamps. Something might be done with waterwheels and dynamos in this way, especially by persons having premises adjoining the river.

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor o we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

HECKLING AT BELL'S ASBESTOS MEETING.

There is an institution long almost sacred to Scotland, and there only used to torture candidates for parliamentary honours, an institution known as heckling. Just, however, as a little leaven leaveneth the whole lump, so heckling seems to be permeating over the whole of these islands, and is especially noticeable at "companies' meetings" in the metropolis. Heckling may be defined as questioning, yet it is not legitimate questioning. It is generally the questioning of an avowed opponent, with the intention of tripping up the one questioned. Ofttimes the biter gets bitten, and then his mood is not to be envied. The meeting of Bell's Asbestos Company the other day was enlivened with a bit of heckling. A shareholder, with one share, and, so far as we could gather, that share given him so recently that his name was not to be found on the register of shareholders, had prepared, or had had prepared for him, a list of a dozen questions which it was evidently thought would lead to unsatisfactory answers. These questions were printed, and distributed at the meeting, were put through after some sharp remarks, and answered very effectively by the chairman, who, in this case, was able to show the questioner or his backers had somehow or other got hold of a mare's nest. However, even in this case the chairman had to refuse point blank to answer one question, as it referred to the internal management of the company. We know absolutely nothing of the questioner at this meeting, and we have no more reason to take up the question as relating especially to Bell's Asbestos Company—we refer to it upon general grounds. At almost every company's meeting such a man is found asking questions. It generally turns out that he has absolutely nothing at stake in the company—is looked upon as a puppet, controlled by strings held by other parties who wish to be unseen, and therefore use a tool. Nevertheless, the prying into the internal management of a company is a nuisance at a public meeting. Competitors successful or unsuccessful are always on the look-out to see how it is done, and a word only is often necessary to enable competition to become keener and more successful. Thus, it may well be that a person interested largely in a rival concern will interest himself to a small degree in the concern whose business he wishes to divert into other channels. It may be safely said, however, that such action is exceedingly uncommon. There is another class whose actions are by no means commendable, which may be entitled company wreckers. For Stock Exchange purposes—that is, for bulling and bearing shares—they circulate all manner of rumours; they ask or get asked questions that have a very ugly look, and which may have a very elastic answer—that is, an answer that may be made to seem different to what it is intended to mean. These men are generally hand-and-glove with a financial paper, and if they can only manage to instil a doubt in the minds of shareholders and the public their end is gained. They can, for a time, play battledore and shuttlecock with prices, and no matter up or down they make money. For some time past there has been a "dead set" at Bell's. The chairman, however, took the bull by the horns, and spoke in pretty straight language on the subject of "tipping" or "commission," which some immaculate, or would - be - thought - immaculate gentlemen have made much of. The system of "tipping" is universal. There is not a reader of this paper who, if he could get a fifty thousand pound order, would hesitate for a moment in giving "com." to the man who influenced that order. Is it fair, then, when a system, good or bad, it is no matter, is general, that directors should be asked by parties that have nothing at stake how they get their business and what "com." they pay for it, and to whom that "com." is paid? We imagine that any *bonâ fide* shareholder can find out how the business is carried on by going to the office and privately investigating. It may even then be politic for directors to withhold certain information, but much more relating to the internal economy of a company can be said privately than can be made public property. The subject of "heckling" is not difficult; questions that really relate to the welfare of a company, and to information it is desirable the shareholders should have, ought always to be answered, but questions that are directed against the welfare of the company, and put for evil rather than good purposes, ought to be met with a blank refusal to answer. Few chairmen are strong enough, many have not the requisite knowledge to adopt this course; but we hope to see a more universal assertion of this principle.

CITY AND SOUTH LONDON RAILWAY COMPANY.

The shareholders of this company, at an adjourned meeting held on Tuesday last, supported the directors in the promotion of a Bill for an extension of their line, or rather for a new line from King William-street to Islington. From the investor's point of view this is clearly a step in the wrong direction. The cost of the City and South London line has been enormous, and it has yet to be proved that sufficient traffic can be obtained to enable a dividend to be paid. Before embarking upon a new and a costly undertaking, it ought to be demonstrated without a shadow of doubt that a return may be earned. Let us look a little more closely into the matter. The capital of the City and South London authorised is £800,000 share capital, and £225,000 of debenture capital, of which practically the whole share capital has been issued, and on debenture account £155,700 has been obtained. There is, then, a sum of £756,000 upon which to pay dividends. A five per cent. dividend takes £37,800, and to earn this, after working expenses have been paid, at twopence per passenger, means carrying 4,536,000 passengers, or about 12,000 per diem. We cannot tell what the working expenses are, but the traffic to pay these expenses is in addition to the above—thus it will be seen the company has a heavy task before it. There may be other means of obtaining income, such as selling surplus land or letting land or buildings, but of this we know nothing. Sufficient, however, can be seen from an examination of these figures to show the problematical nature of a great success, and this should act as a motive for caution in countenancing further extension and the further spending of capital till a moderate success is assured. We may admit that there is sufficient evidence from the traffic returns to cause the belief that the line will be worked at a profit, but that is quite a different thing to knowing that the line is worked at a profit sufficient to pay a modest dividend upon the enormous capital necessary for its construction. At any rate we have uttered our protest against this proposed line, and if speculators are so unwise as to run counter to advice offered to them, not only by ourselves but by other technical journals that have no reason for throwing cold water upon any electrical work, it cannot be said that they have not been forewarned. There is nothing as yet to indicate urgency in this work, although the bogey of "someone else will do it if we don't" may be used to influence shareholders. A very little examination of the subject shows why the proposed line is not to be an extension of the existing line, but a closer examination shows also that the lines will be mutually advantageous whether in the hands of the existing company or in any other. At present you pay twopence and can go the whole distance. If the line were extended, carrying passengers from Camberwell to Islington for twopence would not pay. Thus the break at King William-street means getting double payment from passengers that desire to go over the longer distance without interfering with existing arrangements. First earn a five per cent. dividend, and then proceed.

NAMES.

Almost the last man we should have expected to "gush" after a new name is Mr. Swinburne, and yet he seems to have accepted the "henry" as if it were generally accepted and in universal use. It has been suggested by Kennelly, and is favoured in America, but as yet it cannot be said to have been approved, at least not by any authoritative body on this side the Atlantic. Whatever may be our views of the Institution in other matters, we have a very strong opinion that the Council of the Institution should immediately, upon the suggestion of a new name from a prominent quarter, consider the word, and accept or reject it. We frequently hear of "differences of opinion" in the Council of the Institution, but if that body cannot act as a guide to the profession the sooner it sinks into oblivion the better. The Institution is not a mere body for the getting of papers and making a discussion thereon. It should move the whole body of electrical engineers, not be moved by a small and active section of that body. We might also suggest that some of the papers are rather too discursive—are, in fact, too evidently in need of revision or supervision to be an honour to the Institution or a credit to the reader. Are they always properly submitted to a competent hand before acceptance?

During the past ten years a number of "words" have been coined. That fact shows some terms are wanted, and an authoritative adoption would simplify nomenclature. Years ago we pointed out that a smaller institution, "The Institution of Actuaries," adopted a certain notation and nomenclature, and made it universal in the profession, because they insisted upon its use in their journal. The Institution of Electrical Engineers has more power in the electrical world than the Institution of Actuaries had at that time in the actuarial world, and yet men may use what notation and what nomenclature seems to them good without a hint to the contrary. Certainly some years ago there was a committee formed to consider the question of notation and nomenclature, in which a certain professor took a leading part, drew up certain forms, and then—well, probably, he turned his attention to study electric lighting, and when he has finished that study, in the dim and distant future we may expect to hear something more of the matter. The modern views of electricity seem to want another fundamental "term." Is electricity a phenomenon of the ether? Is the energy of electricity due to the motion of the ether? Is Mr. Preece and his school right in saying what Maxwell called electricity is not the same as what Mr. Preece calls electricity, that, so to speak, there is "electricity" and a "carrier of electricity," and we want a suitable term for the "carrier." Perhaps Mr. Sprague, who seems to doubt modern advances, may have something to say on this subject. At any rate we are certain that the Institution must bestir itself to be an authority on something. Let but some French electrician suggest the idea, and we shall get a congress at Paris—to settle the question. Electricians like Paris congresses.

CORRESPONDENCE.

REFORM IN CONSULTING ENGINEERING.

To the Editor of the Electrical Engineer.

Sir,—I have perused with considerable astonishment the long article in your last issue dealing chiefly with my action in advising the Electric Light Committee of the Dublin Corporation on the acceptance of one or more of the tenders submitted to them.

I regret that the position I now hold in relation to the Corporation prohibits me entering into a detailed refutation of the erroneous statements made therein.

The article in question is a collection of misleading and false deductions, with hardly a spice of truth in it from start to finish. It surprises me, as it doubtless will many other of your readers, that a journal wishing to represent and to advise a profession should publish a substantially incorrect account of proceedings of a committee sitting with closed doors, and of which proceedings therefore your journal could have no authentic knowledge.

I utterly and entirely repudiate the serious insinuations of the article as affecting myself, but as I am leaving town upon urgent business, I must, for the present, be content with requesting you to publish this letter in your next issue.

It is my intention, however, to adopt further measures to clear myself of the imputations made and of which you will hear further.—Yours, etc., E. Manville.

68, Victoria-street, S.W., Feb. 25.

[We would ask Mr. Manville to carefully read our article again. He will then, perhaps, notice points which in his having to attend to urgent business may have escaped him. But in the first place we must say that Mr. Manville is very general, though sweeping, in his condemnation, and that if he will only point out our errors we will give his refutation equal prominence to the original statement. Mr. Manville ought to see that our condemnation was intended to be against a system, which system we believe to be utterly wrong, and that no personal imputation was or is made. We start our argument with the statement that "the whole system of tendering was a wrong one." We admit it was following precedent, and we say "The engineers at Dublin followed the rule, bad and condemnable as it is, and can only be said to have erred." As stated at the end of our article, we have no desire to do other than compel an alteration of this system, so that the position now stands:

1. We attack, or intend to attack, a system.
2. Mr. Manville assumes we attack him, while, in reality, there was not the slightest intention of so doing.
3. Mr. Manville says our "deductions" are incorrect. This is very immaterial, if the facts are correct. The best logician may err in his deductions, and we are not infallible.
4. Mr. Manville accuses us of making "serious insinuations" against him. If to say he has erred by following precedent is a "serious imputation," we accept the soft impeachment, though where the seriousness or the insinuation come in it is difficult to say.—Ed. *E.E.*]

TRANSFORMER DISTRIBUTION.*

BY J. SWINBURNE, MEMBER.

The distribution of electrical power by means of alternating-current transformers can hardly be considered to have reached its final state, and though it may be somewhat difficult to say what system will be in general use 10 years hence, there is little doubt that present practice will be largely superseded.

The method now in vogue is simple: it consists of running several independent dynamos, each with its own engine; each dynamo supplies a few high-pressure mains, which branch off, and supply transformers placed in the houses, or wherever light is required. This system, admirable for country towns or straggling villages, is hardly likely to be permanent anywhere else. It has many disadvantages. Except that all the dynamos and engines are in one building, it is nothing more than a collection of little independent installations. Each engine and dynamo supplies its own circuits, which are independent of all the others. In cases of a breakdown of an engine or dynamo, and in many cases of the leads, there is a stoppage till new arrangements can be made at the station. In addition to this, great lengths of high-pressure conductor are required, and this leaves openings for breaking down of insulation. The introduction of high pressures in private houses is dangerous if not well managed, and is in any case expensive, demanding compliance with all sorts of regulations, rendered necessary for the security of the public. The greatest drawback to the present system, however, lies in the waste of power in the transformers themselves. For a long time transformers were supposed to have an efficiency of about 98 per cent. More will be said on this subject presently.

It must be borne in mind that in spite of the drawbacks of the present system of putting transformers in houses, it may be, and probably has been, advisable for electric light companies to begin on that system, even in such places as London; but I do not think such an arrangement will pay in the long run, and a time will arrive when the mains will have to be changed and a low-pressure supply system substituted. When an electric light company begins, it has to take on houses here and there, where it can get them; but if its district is populous and wealthy, it should soon be enabled to work on some low-tension or sub-station system; and then the question is whether it is not better to lay the low-pressure mains at first, instead of beginning on one system and changing to another. Probably none of the existing companies mean to change from one system to another. Their engineers have no doubt gone into the merits of the particular cases, and have come to their conclusions with great deliberation, and I do not think it well to offer any criticisms lightly.

Parallel Running according to Orthodox Hypothesis.

To begin at the beginning of my somewhat extensive subject, the first question is that of running machines in parallel. There are few matters of greater importance to engineers, and few on which opinions differ so widely. One says that machines will not run in parallel unless they have large self-induction; another, that it is necessary to have iron in the armatures; another that they will only run together if they have no self-induction, or as little as possible. Others say that there is no difficulty in running them in parallel. No engineer who employs direct currents denies the advantages of running machines in parallel; if independent running is advisable in alternate systems, it is equally advantageous in the case of direct currents, and direct-current stations should have separate circuits for each little district, each district being run by one dynamo. I do not think, therefore, independent running is advisable.

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* Paper read before the Institution of Electrical Engineers.

In 1884 Dr. Hopkinson showed that alternate-current dynamos could be run in parallel, or could be run as dynamo and motor, and even that a machine giving a high pressure could be run as a motor off a circuit of lower pressure. In his paper he assumes that machines have "self-induction." He points out that the self-induction varies, but that it would be impossible to work out the calculations if the "self-induction" were taken as variable. For some reason or other, Dr. Hopkinson's calculations have received little application. That is to say, engineers have not taken actual cases and worked them out. Calculations have been made in which the various quantities have appeared in the form of letters, and diagrams have been drawn in which they are represented by lines whose lengths have been chosen at random. The geometrical treatment of many problems of this kind shows most of the actions very clearly to students, but is not always of value in practical work, as in most cases some lines are so long and others so short that it would be difficult to avoid large errors. The result of this is that few of us, if any, have had a definite idea of how much "self-induction" a machine should have to make it work well in parallel with others. The general impression is that it is somewhat difficult to design a machine whose "self-induction" is large enough, and that most failures to run in parallel are due to deficiencies in this respect. I am using the term "self-induction" under protest, as I prefer to look at the question from another point of view. But whatever goes on in a dynamo, if the no load E.M.F. is treated as constant, a value for a constant coefficient of self-induction can be assumed which would produce results somewhat similar to those found in practice. To overcome the difficulties arising from deficient self-induction in the armature circuit, Dr. Hopkinson has proposed to insert it artificially, in the form of choking coils, or to use induction couplers to compel synchronism. Without knowing that it had been done before, I described a similar arrangement to the Institution a few years ago.

In the spring of 1890 Mr. Mordey read a most important paper, in which he described some experiments on alternate machines. He argued from them that self-induction was deleterious, and that machines would run together best if they had none. In the discussion, Dr. Hopkinson pointed out that the experiments were quite in accordance with his theory, and that there was nothing that could not be foretold by it.

To begin with, it is necessary to get a clear idea of what is required for parallel running. It is not exactly the same as the case of alternating motors, neither is it the same as two machines of equal pressure coupled in parallel by themselves. If all the machines are coupled to two main conductors, we may consider them one at a time, and take each dynamo as coupled to a system whose pressure and variations of pressure are independent of it. Suppose the effective pressure to be 2,000 volts, for example: we have to consider a pair of mains with 2,000 volts, and we have to couple on a dynamo to add so many amperes to it. Such a machine must be excited to give 2,000 volts on no load, being then thrown into circuit with full steam turned on immediately afterwards. It should be excited to give somewhere about half load with 2,000 volts at the terminals, and should then be thrown in. Steam can then be turned on, and the excitation raised to its normal value. The machine should be so designed that any excessive power that the engine may give shall not only not throw the machine out of step, but shall not increase the armature current to such an extent as to damage the insulation by excessive heating.

The power absorbed by a dynamo working on a parallel system is

$$P=\frac{B^2 r}{2 i^2}-\frac{A B r}{2 i^2}\cos 2\pi n\tau+\frac{A B L}{2 i^2}\sin 2\pi n\tau,$$

where A is the maximum station E.M.F.—that is to say, the station pressure is A $\sin 2\pi n\tau$—B is the maximum "impressed" E.M.F. in the armature, r is the armature resistance, i the impedance of the machine, and τ the angle of lead. This equation is taken from Dr. Hopkinson's paper. When the dynamo is doing its proper share—that is to say, under normal conditions—

$$B=I c,$$

where I is the impedance of the whole circuit when the machine is isolated, and working at full load on an external resistance, and c is the maximum value of the current. To find how much the driving power may increase for a small increase of current, we may differentiate with respect to c, and then find the value of L which makes the result a maximum.

$$c=\sqrt{\frac{A^2+B^2-2AB\cos 2\pi n\tau}{i^2}}.$$

$$\operatorname{Cos} 2\pi n\tau=\frac{A^2+B^2-i^2c^2}{2AB}.$$

So,

$$\frac{dP}{dc}=\frac{ABr}{2i^2}\cdot\frac{i^2c}{AB}+\frac{AB\,2\pi nL}{2i^2}\cdot\frac{d\sin 2\pi n\tau}{d\,2\pi n\tau}\cdot\frac{d\,2\pi n\tau}{d\cos 2\pi n\tau}\cdot\frac{d\cos 2\pi n\tau}{dc};$$

and in the case of a dynamo working on resistance, or on a station load when supplied with just its right share of power,

$$\cos 2\pi n\tau=\frac{A+rc}{B},$$

$$\text{and } \operatorname{cosec} 2\pi n\tau=\frac{B}{Lc}.$$

So,

$$\frac{dP}{dc}=\tfrac{1}{2}A+cr,$$

c being the maximum, not the effective current. It will be observed that L has disappeared altogether.

This shows that for a very small increase of power the increase of current will be the same, whatever the self-induction of the machine may be. It would not matter if the machine had none. A machine with no self-induction would (Mr. Mordey notwithstanding) short-circuit the mains if the engine supplied too little power; in fact, at full load it would be giving its minimum possible output, and any attempt to diminish this would be disastrous.

Discussing the question of a very small increase is not exhaustive; an engine may supply a large proportion more than its share of power to one machine. For instance, suppose it supplies twice the normal power. Many engines could not give such an excessive power, but in others which have expansion gear controlled by a speed-governor it is easy to get double power if the station is running at a slightly slower speed than that for which the governor is set.

These matters are always made much clearer by taking practical examples and working them out. The great difficulty is to obtain accurate data. I should prefer to discuss such machines as those described in Mr. Mordey's paper read here a short time ago. Without wishing to say anything in disparagement of his excellent paper, I must point out that an account of experiments should contain full particulars of the machines on which the experiments were made. Such omissions are exceedingly common in electrical papers. Mr. Mordey has not given us the details of the field magnets, air space, armature coils, or exciting coils; he has not even given us the currents in the different experiments. I have found similar omissions whenever I have tried to gain information from any of the numerous experiments which have been made on alternate machines in America. Mr. Mordey does, however, say that about half the drop in his machines is due to resistance, and half to self-induction. The machines give an output of 2,000 volts and 20 amperes, and when fully excited give 2,200 volts at no load. This would correspond to a self-induction of 0·05 henry.

Suppose, first, that the self-induction were such that $2\pi n L=r$: on increasing the power supply, the effective current increases evenly, and when the power supplied to the machine is doubled, the effective current is only about 44 amperes. It is necessary, however, that the machine should stand decrease of load, as well as increase, without injury. Keeping the same self-induction, let us decrease the load to zero with the full excitation on. The current gradually diminishes to just below 15 amperes, and then increases to just over 20 again.

These figures are extremely troublesome to work out from Dr. Hopkinson's equations, as the angle is so small that an error in about the sixth place of decimals will vitiate the results.

Many people prefer diagrams such as those used in mathematical books when dealing with harmonic variations. Mr. Blakesley has applied these diagrams to the discussion of alternate dynamos and motors, and Messrs. Kapp, Fleming, and others have applied them too. The chief drawback is that it is not always easy to draw such figures to scale. They are generally drawn with the values taken at random, to give ideas of the principles involved. So far as I know, no scale diagram of this sort has ever been published. In the case of the 40,000-watt machine such diagrams can be applied; but with 100,000 machines, which will probably be the standard size, the diagrams are almost illegible.

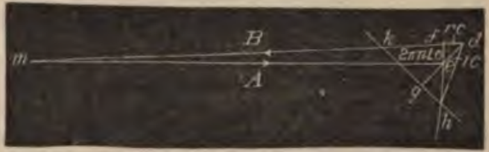


FIG. 1.

Fig. 1 is a diagram to scale. The lines are all rotating positively. The diagram is made as follows: The pressure in the mains, A, is drawn first. Instead of the maximum, it is simpler to draw the effective pressure—in this case 2,000 volts. From the end e, $2\pi n L c$ is drawn at right angles to it to f; and then $r c$ from f, parallel to A, B, is drawn to join the ends of A and $r c$, as shown. The lines are all pressures, but the instantaneous current is in step with the pressure $r c$ and with the pressure A, so that the power is proportional to B $r c \cos f d m$. I use the expression "in step" to mean co-phasally synchronised. Thus two machines may be running at the same speed without being in step, just as soldiers may take the same number of paces per minute without being in step.

To find the current at double load, produce $i c$ to g, so that $d g=2 i c$. Through g draw a straight line cutting B at k, at an angle, $g k d$, equal to the angle $d e f$. The line $g k$ is the locus of the end of the line representing the pressure spent over the resistance and self-induction of the armature with currents giving double load. It is unnecessary to go into the proof of this. With

m as centre and A as radius, describe arc cutting kg at h; join dh. Then the current at double load is to 20 amperes as dh is to de. In this case the double-load current is not much more than 40 amperes.

To find the current at half-load, bisect de, and through point of bisection draw a straight line parallel to hk, and proceed as before. The no-load line, of course, passes through d.

Let us now assume the self-induction to be 0·05. The resulting diagram is shown in Fig. 2. The double-load current is almost exactly 40 amperes.

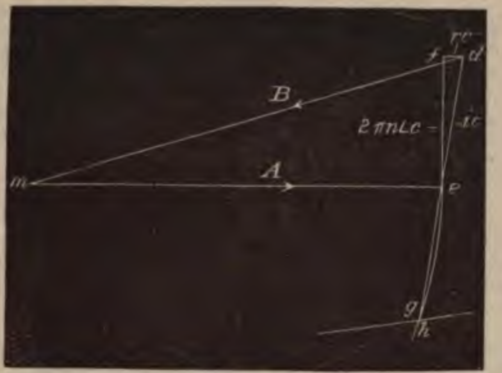


FIG. 2.

Take now the case of a 10,000-watt machine with a self-induction of 0·1. At double load the current is 50 amperes, and at no load it is only 1·6 amperes. If the machine has a self-induction of much more than 0·1 quadrant, the current at double load begins to increase rapidly. It is thus clear that the self-induction may have any value between 0·008 and 0·1 and the machine will work perfectly in parallel.

We have only taken small machines. Mr. Kapp recently described a 60,000-watt machine with an armature resistance of 1·74 ohm, and a self-induction of 0·0955—say of 0·1. We may see how it will work in parallel. The pressure is 2,000 volts, and the frequency 80. This case cannot be shown clearly in a diagram, as rc is very small in comparison with $2\pi n Lc$ or B. The result is, however, that the machine cannot possibly take double power from the engine; it falls out of step first. Now 60,000 watts is not a large output for central stations, and it is probable that 100,000 will be about the size adopted. The "time constant" of such a machine is considerably greater. We thus find that according to the self-induction hypothesis the difficulty does not lie, as commonly supposed, in getting enough self-induction in the armature; the trouble is that there is generally too much. But in machines from 25,000 to 50,000 watts it is exceedingly difficult to make dynamos that will not run perfectly in parallel, so great is the permissible margin of self-induction. It must be carefully borne in mind that so far the armature has been supposed to have a constant coefficient of self-induction, and the pressures of current are assumed to vary harmonically.

The orthodox hypothesis thus tells us that with ordinary sizes of machines it is exceedingly difficult to design them so that they will not run in parallel. Either, therefore, all ordinary machines run perfectly in parallel, or the assumption that alternating currents follow sine laws, that machines have coefficients of self-induction constant throughout each period, or that they have coefficients of self-induction constant for different armature currents, is too far from the truth to be useful; or, in legal language, one or some or any or all of them must be wrong.

(To be continued.)

PHYSICAL SOCIETY.

The annual general meeting of the above society was held on February 13, Prof. A. W. Reinold, F.R.S., past president, in the chair.

The reports of the council and treasurer were read and approved. From the former it appears that there has been a satisfactory increase in the number of members and in the average attendance at the meetings. During the year a translation of Prof. Van der Waal's memoir on "The Continuity of the Liquid and Gaseous States of Matter" has been issued to members, and it is hoped that the translation of Volta's works, now in hand, will be published before the next general meeting.

The council regret the loss by death of Mr. W. H. Snell and Mr. W. Lant Carpenter, and obituary notices of these late members accompany the report.

The treasurer's statement shows that the financial condition of the society is very satisfactory, and that the sales of the society's publications have increased considerably.

A vote of thanks, proposed by **Mr. Whipple** and seconded by **Dr. Gladstone**, was unanimously accorded to the Lords of the Committee of Council on Education for the use of the room and apparatus.

Dr. Atkinson proposed a vote of thanks to the auditors, Prof. Fuller and Dr. Fison, which was seconded by **Dr. Thompson** and passed unanimously. The proposer, in referring to the satisfactory nature of the accounts, recommended that the publications of the society should be brought before physicists and other students of physical science, and Dr. Thompson heartily concurred in this recommendation.

A third unanimous vote was accorded to the president and officers for their services during the past year, the proposer and seconder being **Dr. Waller** and **Prof. Minchin**.

The following gentlemen were declared duly elected to form the new council: President, Prof. W. E. Ayrton, F.R.S.; vice-presidents, Dr. E. Atkinson, Walter Baily, M.A., Prof. O. J. Lodge, D.Sc., F.R.S., Prof. S. P. Thompson, D.Sc.; secretaries, Prof. J. Perry, F.R.S., T. H. Blakesley, M.A., M.Inst.C.E.; treasurer, Prof. A. W. Rücker, M.A., F.R.S.; demonstrator, C. V. Boys, F.R.S.; other members of council: Shelford Bidwell, M.A., LL.B., F.R.S., W. H. Coffin, Major-General E. R. Festing, R.E., F.R.S., Prof. G. F. Fitzgerald, M.A., F.R.S., Prof. J. V. Jones, M.A., Rev. F. J. Smith, M.A., Prof. W. Stroud, D.Sc., H. Tomlinson, B.A., F.R.S., G. M. Whipple, D.Sc., James Wimshurst.

The meeting was resolved into an ordinary science meeting, and Messrs. W. Thorp, B.Sc., G. W. Yule, and S. Joyce were elected members of the society.

A paper **"On the Change in the Absorption Spectrum of Cobalt Glass Produced by Heat,"** by **Sir John Conroy, Bart., M.A.**, was read by Mr. Blakesley. The absorption spectrum of cobalt glass when cold consists of three dark bands in the red, yellow, and green, with a considerable amount of absorption between the first two. When a piece is heated to nearly red heat, the absorption between the first two dark bands diminishes, and the band in the red moves towards the least refrangible end of the spectrum, whilst those in the yellow and green retain their position, but become less distinct. During the heating of the glass the intensity of its colour diminishes, and as the glass cools its original colour and absorption spectrum returns. Diagrams and numbers showing the character and positions of the bands in hot and cold glass accompany the paper, together with the numbers obtained by Dr. W. J. Russell (*Proc.*, Royal Society, 32, p. 258) for cold cobalt glass. In conclusion, the author says that these observations, and those of Feussner on solutions, show that the absorption spectra of some substances vary with temperature. In solutions, this may be due to formation of different hydrates, or to partial dissociation, but in a solid like cobalt glass an actual change in its chemical constitution at a temperature considerably below its fusing point does not seem probable. **Dr. Gladstone** said it was generally known that heat affects the colouring power of substances, and that in solutions absorption is greater the higher the temperature. Different solvents sometimes produce effects analogous to heat, for cobalt salt dissolved in water and in alcohol give pink and blue solutions respectively, and rise of temperature makes the aqueous solution more blue. He concurred with the author as to the causes of the phenomena in liquids, and that the same explanation would not apply to glass. **Prof. S. P. Thompson** thought Sir John Conroy's results agree with the experiments which Mr. Ackroyd showed before the society some years ago, when he demonstrated that the colours reflected by opaque bodies, such as porcelain, etc., when heated, tends towards red. **Prof. Minchin** showed some experiments in illustration of his paper on "Photo-Electricity," read at the previous meeting. In one of these, a seleno-aluminium battery, illuminated by the light of a taper, deflected an electrometer needle, thereby actuating a relay and ringing a bell. He afterwards exhibited one of his "impulsion cells" in action, and showed the change from the insensitive to the sensitive state produced by a Hertz oscillator at a distance. During the discussion, **Mr. Tunzelmann** said Kalischer and Von Uljanin had worked at the same subject, the former being the first to make experiments on a photo E.M.F. in selenium. His cells were made by winding brass wires on glass tubes and coating them with selenium, which was subsequently annealed. These cells lost their power after some time and would not respond to feeble lights. By using two wires of different metals he obtained better results. Fritts, in 1883, used brass and gold plates coated with selenium, and Uljanin employed platinum plates deposited so thin as to be transparent. The latter experimenter found that the E.M.F. was proportional to the square root of the intensity of the light. He also observed that the orange-yellow of the prismatic spectrum produced the greatest effect, whereas the yellow-green and the green rays of the diffraction spectrum gave the maximum E.M.F. Comparing these results with Langley's observations on the energy of the spectrum, it would appear that the E.M.F. bears no relation to the maximum energy falling on the surfaces. Speaking of the cause of the phenomena, he said the electrolytic idea of Von Uljanin seemed inapplicable to Prof. Minchin's results, and he enquired whether a mixture of selenium and aluminium would undergo a gradual change by exposure to light. **Dr. Gladstone** said such a change, if it occurred, would be very slow, for nearly all difficult chemical reactions take time to complete. The fading of colours was adduced as an instance of slow chemical change produced by light. **Dr. Waller** thought the subject might throw light on the changes occurring in the retina, and asked if it was possible to separate thermo-electric and photo-chemical effects? **Dr. Burton** said he had suggested that the action of light on the retina was a photo-chemical one some time ago; but hitherto it had been difficult to obtain substances sensitive to any but the blue and violet rays, whereas the eye was most sensitive to green and yellow light. In the photo-electric batteries, however, the E.M.F. may generate a current, and, therefore, energy, and the important question seemed to be: Where does this energy come from? Is it a chemical change precipitated by the action of light, or does a direct conversion of light and electric energy occur? **Prof. Minchin**, in his reply, said he thought his cells really transformed the incident energy. They were usually kept on open circuit, and there appeared to be no deterioration with time, the only change being a sluggishness in developing their maximum E.M.F.

BIRMINGHAM.

The following is the report to the Birmingham City Council of the Public Works Committee:

This committee report that by section 22 of the Birmingham Electric Light and Power Order 1889, the Corporation are required to appoint and keep appointed one or more competent and impartial person or persons to be electric inspectors for the purpose of inspecting electric lines and works, and of certifying meters under the order. The testing places and instruments for testing the mains and services are to be provided by the undertakers, the number of stations and their distance from the mains to be fixed by the Corporation, or in case of dispute to be settled by the Board of Trade. The undertakers are also to provide upon all premises from which they distribute electric energy suitable and proper instruments, approved by the Board of Trade, for recording observations; the instruments and the records to be open to inspection by the inspector. The inspector, when required to do so by the Corporation, shall test the mains, and, when required by a consumer, shall test the service lines, for insulation and conductivity. He is to give notice to the undertakers before commencing any tests, who may be represented thereat, and on the day after such testing he is to deliver a copy of his report thereon to the undertakers. All expenses of such testing, including reasonable fees to the inspector, are to be paid by the undertakers, unless the inspector's report show that the authority or person was unreasonable in requiring the test to be made, when the expenses and fees shall, on application by the inspector, be ascertained by a court of summary jurisdiction and paid as directed by the court. The inspector is also to certify the meters to be used, and any difference between the undertakers and their consumers as to the correctness of any meter is to be settled by the inspector. The fees to be paid for testing the mains, service lines, etc., and certifying meters, are to be prescribed by the Corporation and approved by the Board of Trade.

ABERDEEN.

REPORT OF THE GAS SUB-COMMITTEE.

Mr. Alexander Smith, manager of the Corporation Gas Works, has, in compliance with the request of the Gas Sub-Committee, prepared a report on the expense of erecting an electric lighting station to supply the compulsory area, and the probable annual revenue that would be derived therefrom. The consumers in the compulsory area (which comprehends Union-street from the Townhouse westwards to Bridge-street, Market-street between Union-street and Guild-street, and St. Nicholas-street), whose yearly accounts for gas are over £5, consume 27½ million cubic feet of gas per annum. To replace this, 600,000 units of electricity would be required. On the assumption that one-fourth of these consumers would take electric light in place of gas, 150,000 units of electricity must be generated yearly. Mr. Smith has been in communication with Mr. W. B. Esson, electrical engineer, London, and taking into account that the machinery will require to be of greater power to meet the demand in winter, Mr. Smith finds that dynamos having an aggregate capacity of 2,000 16-c.p. lamps would be necessary. He accordingly recommends that two machines of 1,000 lights each be obtained, leaving space for additional machines to be put in as they may be required. Each dynamo would be driven by a compound engine of 150 h.p. For providing steam to the engines, three water-tube boilers would be erected, one to be kept as spare. The cost of distributing cables, opening ground, etc., would be at the rate of 32s. per yard. The charge of 9d. per unit of electricity is the maximum allowed by the provisional order.

Mr. Smith then gives a statement of the probable cost of erecting the necessary buildings and laying down the plant, and of the estimated revenue and expenditure. The cost is as follows:

Engines, connections, water-heaters, lifting apparatus, dynamos, and controlling apparatus	£2,800
Boilers and economisers	1,700
Storage cells	3,500
Meters	1,600
Distributing cable, including street boxes for leading off service lines	4,200
Buildings, machinery, foundations, and boiler settings	3,500
Ground	3,000
Incidents and utensils	1,000
Total	£21,300

The annual revenue is estimated thus—150,000 units of electricity at 9d. per unit, £5,626; meter rents, £150—total, £5,875.

Mr. Smith estimates the annual expenditure at £4,556. 10s., leaving an estimated profit of £1,318. 10s. The expenditure is made up by allowing on storage cells, interest, and sinking fund at the rate of 5½ per cent., and for depreciation, repairs, and renewals 15 per cent.; on meters, interest, and sinking fund at 5½ per cent., and for depreciation, etc., 10 per cent.; on machinery, interest, and sinking fund at 5½ per cent., and on depreciation, etc., 10 per cent.; on buildings, interest, and sinking fund at 5½ per cent., depreciation, etc., 5 per cent.; on ground, interest, and sinking fund 5½ per cent. Fuel is estimated to cost £575; wages and management, £600; water and taxes, £120; incidentals, £150.

The profit of £1,318. 10s. is brought out on the assumption that 150,000 units will be sold. Whether this quantity is disposed of or not, the whole of the expenditure will remain the same with the exception of fuel, oil, and water, and assuming that only 100,000 units were sold, the above profit would not only be wiped out, but over £350 of annual loss would be shown. He is, therefore, of opinion that it would be advisable, before laying down so expensive works and machinery, to ascertain the number of consumers that may be expected to take a supply, and whether there is any likelihood that the estimated quantity of electricity will be disposed of. Mr. Smith then makes the statement that the cost of electricity supplied to the estimated number of consumers in the compulsory area would be, as above stated, £5,875, and that these consumers would receive the same lighting power in gas for the sum of £1,350.

In the event of the Town Council not proceeding themselves to erect a station, Mr. Smith mentions that Mr. Esson recommends that offers from electrical companies should be invited by advertisement, with a view to one of those companies becoming transferees of the Corporation for the purpose of undertaking all their obligations with respect to electric lighting. This course has been followed by the Corporation of Glasgow.

In conclusion, Mr. Smith gives the comparative cost of two different qualities of gas with one Board of Trade unit of electricity. This shows that while one Board of Trade unit of electricity costs 9d., 48 cubic feet of 28 c.p. gas (equal to one unit of electricity) would cost (at the rate of 3s. 8d. per 1,000 cubic feet) 2·112d., and 54 cubic feet of 25 c.p. gas (equal to one unit) 2·376d.

COMPANIES' MEETINGS.

CITY AND SOUTH LONDON RAILWAY.

The following is the report of the Directors:

It is with much satisfaction that the Directors have to report that the railway has been completed, and was opened for public traffic on 18th December last. The running of experimental trains suggested the necessity for a number of minor improvements in the tunnels and working appliances, the carrying out of which caused some delay; but on the 4th of November the completion of the line was graciously inaugurated by H.R.H. the Prince of Wales, accompanied by H.R.H. the Duke of Clarence. This ceremony was followed by several weeks' private running of the trains, so that the staff might be fully instructed in their somewhat novel duties, and on the 18th of December the railway was opened to the public. Since that date a service of trains, running at intervals of about five minutes, has been maintained, and although there have been a small number of occasional delays, from the failure of engines and other causes, there is every reason to be satisfied with the use of electricity as a motive power, and when the various improvements, suggested by experience, are all carried out it is anticipated that the line will prove one of exceptional safety and comfort, and will be worked with economy and regularity. During the short time the railway has been working the average number of passengers carried has been about 15,000 per day, but as the weather improves, and the line is better known, this number will no doubt steadily increase. It has been found in working such a rapid service that the siding accommodation provided is insufficient, and arrangements are now in progress for the construction of additional sidings at the Stockwell terminus, which will add greatly to the facilities for working the line. The Board of Trade have recommended the addition of a fourth engine and dynamo to the generating plant at Stockwell depot, and these have accordingly been ordered, and it is intended also to add two additional trains and four additional locomotives to the rolling-stock. As soon as these additions are complete, it will allow of a considerable accession to the number of trains run, and the opening of the line on Sundays, if thought desirable. The accounts for the past half-year have been made out in the form previously adopted, but as the Company is now recognised as a railway the accounts in future will be rendered in the form prescribed by the General Railway Acts. As the line was only opened a few days before the close of the half-year, it has not been thought necessary to create a separate revenue account for that short period. With the view of developing the traffic on the line, a Bill has been deposited in Parliament to authorise the construction of a branch line from King William-street to the Bank, and thence under Moorgate-street, Finsbury-pavement, and the City-road to The Angel at Islington. It is anticipated that this line, when made, will bring upon the existing railway a large additional traffic during that period of the day when the trains are at present not well filled, in addition to being itself a remunerative undertaking, will add greatly to the value of the present railway, as affording access to the heart of the City traffic, and a much-needed direct communication between the northern and southern suburbs of London. The calls upon 26 shares having been long in arrear, a formal resolution will be proposed confirming the forfeiture of the shares, and authorising their being dealt with. The Directors retiring by rotation are Mr. Walter Robinson and Mr. Sampson Hanbury, who are eligible for re-election. The Auditors also retire, but offer themselves for re-election

Share capital authorised 1884, £300,000 in 30,000 £10 shares
,, ,, 1887, £300,000 ,, 30,000 ,,
,, ,, 1890, £200,000 ,, 20,000 ,,
£800,000

Debenture capital authorised 1884, £100,000
,, ,, 1887, £75,000
,, ,, 1890, £50,000
£225,000

BALANCE-SHEET FOR HALF-YEAR ENDING 31ST DECEMBER, 1890.

		£ s. d.	£ s. d.
Share capital—Subscribed capital		600,000 0 0	
Amount received on shares issued			599,838 0 0
Debenture account — Amount created		175,000 0 0	
Amount received on debentures issued			155,700 0 0
Sundry creditors (exclusive of liabilities on purchases of property not completed		8,744 16 11	
Contractors' retention fund account		31,354 10 0	
Amount advanced in respect of parliamentary deposit 1887 and 1890 Acts		17,001 18 0	
			57,101 4 11
Traffic receipts 18th to 31st December (11 working days)		1,568 3 9	
Less traffic working expenses		1,042 6 0	
			525 17 9
			£813,165 2 8
		£ s. d.	£ s. d.
Expenditure—As per last account.		606,628 1 4	
Expenditure during half-year	£75,203 18 3		
Issue of capital	44,794 1 8		
		119,997 19 11	
			726,626 1 3
Administration expenses—Salaries, office rent, Directors' and Auditors' fees, law and sundry expenses		2,230 2 1	
Less transfer fees.	£5 17 6		
,, interest	83 16 8		
		89 14 2	
			2,140 7 11
			£728,766 9 2
Land and property—As per last account		53,919 11 6	
Additions during half-year	£1,843 16 4		
Less rents received and deposit on property sold	298 10 0		
		1,545 6 4	
			55,464 17 10
Parliamentary deposit 1887 and 1890 Acts			17,001 18 0
Sundry debtors			7,166 1 9
Stores on hand			373 9 0
Cash on deposit at bankers and in hand			4,392 6 11
			£813,165 2 8

The thirteenth ordinary general meeting of this Company was held at Winchester House on Tuesday, the Chairman, Mr. Charles Grey Mott, presiding.

The **Secretary** (Mr. H. H. M. Smith) having read the notice convening the meeting,

The **Chairman** said: Gentlemen, I propose to take the report as read if no one has any objection. In moving its adoption, I have the pleasure of meeting you at last with an opened line, a completed line, and a line earning and at work. Now you all know that in new undertakings of this kind, where so much is new and so little can be got by experience of the past, there is always the feeling of uncertainty that however much you may have studied the question, however much care you may have taken in the commencement of your works and in all the arrangements that you are making, there may yet be something which you have overlooked, which, after all, may render all your labours and all your care of no effect. Now, in an undertaking so new in all its parts as this has been, we were specially open to such a possibility. I am thankful to feel that we have in the experience of this line since its opening the satisfaction of knowing that no serious defect in our calculations has been apparent. I consider that for a new line, new in construction, new in working, new in all its arrangements, it is an unqualified success. Now, if you look back upon the past and what we have gone through for the moment, you will recollect that the construction of this line was one that had never before been adopted. We successfully overcame all obstacles, and we have a line that has been, so far as we can see at present, satisfactorily constructed. There may be certain points, and there will no doubt be certain minor points, in which improvements can from time to time be made, but, as a whole, we can congratulate ourselves that the line, as far as construction goes, has turned out satisfactorily. The next and most important question was the motive power. You know, we were told that electricity was new for a thing of this kind, and that it probably would fail. A great many objections were taken outside to the course that we proposed to adopt, and I confess it was with very considerable anxiety of mind that I and my fellow Directors had to come to you and recommend the adoption of a system which was entirely and absolutely untried. It is satisfactory to feel that we have not been disappointed. The success of our running of these engines (electrical) has been most decidedly marked. We have had no serious drawbacks. You have seen in the papers a great deal about the breakdowns upon this railway, but I venture to say that with such a new system, and such an enormous number of trains as we have run, that it is surprising that those breakdowns have been so few and unimportant as they have. We have carried 900,000 passengers since we opened at Christmas, or two or three days before, in perfect safety. We have run our engines and trains 60,000 miles over the line. We have received in money about £7,500, or equal to 15 passengers per train mile. Of course, in a metropolitan system like this, you expect a very large number of passengers per train mile; very different to the number on a great system like the North-Western or the Great Western, where the number is only 3 or 3½. But, considering that this is so new, that we have absolutely never advertised the line in any way, that we have only dealt with the traffic that has come to us, and we have been compelled to deal with, considering that, I think that we may say that our traffic on the whole has been very satisfactory. We have not encouraged it, we have not tried to draw traffic to the line, because we felt that the first thing was to work the line with the traffic that came to us satisfactorily; that we were not justified in encouraging traffic until this was the case. Therefore, you must not be surprised if the receipts of the line are not as much as perhaps we had hoped, and as we have not the slightest doubt they will be in the future. You will no doubt wish that I should say something about the expenses of the line if I can. Well! I don't feel justified in making any definite statement upon that subject. You must know that at the commencement of a line of this kind we have had to go to a great many extra expenses, because we had to make security doubly sure. But as the line is now settling down into more steady working, we are from week to week reducing these expenses, and finding out small economies from day to day. We have had such a short experience of the cost of working at the present moment, that it would be utterly wrong in me to give any approximate statement on the subject. But I may say this, that as regards the motive power, I feel quite sure that when we come to settle down properly, we shall find that the cost of werking this line by electricity will be decidedly cheaper than working it by steam. Now the receipts of the line per train mile run I can deal with, because that is an ascertained fact at the present moment. Our actual receipts per train mile have been 2s. 6d. The receipts on large railways, such as the North-Western and Great Western, amount roughly to something under 5s. per train mile. That is double what our receipts are at present. But you must remember, on the other hand, that the trains that we are running are only about one-fourth, perhaps one-fifth the weight of the trains which are run upon these lines; and that, therefore, we have really, weight for weight, nearly double the actual earnings per train mile of these lines. I have good hopes and expectations that we shall raise our receipts per train mile to a similar amount to that earned on these lines—viz., 5s. and then you will see at once that we stand in a much better position to deal with our traffic, having only one-fourth the weight to move to earn the same money that they get. I hope that when we next meet we may be able to deal definitely with the cost of working this line. But as the accounts cannot be made up to-day, and we have only some five or six weeks' traffic to deal with, I cannot give you accurate information as to receipts and expenditure. We have found that we could work the lines more economically, and with greater regularity in every way, if we had additional sidings underground. Of course, we did not know until we tried what was absolutely requisite on this head, and we therefore propose, as mentioned in the report, to construct some additional sidings at the Stockwell end of the line. At present we shall construct a small portion of the Clapham extension, which will serve as sidings, and form part of that line. Therefore the money won't be wasted. The Board of Trade suggested that we should have a fourth engine and dynamo in our engine-house at Stockwell. We have three now, two of which work the line, while the other is in reserve. But looking at all the possible risks connected with electricity, of which no one has very accurate knowledge at the present day, we thought it better to comply with the Board of Trade suggestion, and we have therefore ordered another engine and dynamo, and they are now in course of construction. When they are finished we shall have double the power that we ordinarily require. If ever we carry out the Clapham extension that engine will come into use, and the cost will all be part of the same expenditure, and will afterwards be a saving. We find, also, that we are short of rolling-stock, and want a little more in order to multiply the number of trains. You know that at certain times, morning and evening, our trains are overcrowded. We are gradually increasing the number of trains at those times, and we hope to give such a service very shortly as will completely deal with all the traffic comfortably and satisfactorily. But to do that we must have more rolling-stock, and we have therefore ordered additional engines and carriages. I dare say those who have had experience of undertakings of this kind know that when the line has been constructed there is generally a difficulty between the company and its contractors, which, unfortunately, too often ends in legal proceedings, and a long and expensive arbitration or lawsuit. Our contractors, as is usual in such cases, made certain definite claims upon us for extra works, about which there was, as there usually is, difference of opinion between our engineers and them, which might have resulted in a long and expensive lawsuit. Not desiring to have such contentious matter and to waste money in that way, we had a friendly conference with our contractors, and I am glad to say that on thoroughly discussing the affair we have arrived at a settlement which has been approved by both parties. I refer, of course, to the contractors for the construction of the line, and not to the other works, such as rolling-stock, etc., which are not yet completed. We have settled the whole thing with them, and arranged as to the payment of all the balance due to the contractors. That is satisfactory—we have no law proceedings, and we leave off with satisfaction on both sides.

Now I had better deal with the question that is in the report, and that is the extension of the line to Islington. I confess for my own part, and my feelings are shared by the Directors, that if we could have avoided extensions we should done so. We got the power for the Clapham extension, but we have not exercised it, and do not intend to do so until we are satisfied that it will add to and improve our present line. But we found in working this line that there were certain things which, using our best judgment and discretion, did make it desirable that the line should be extended in the direction which we now propose to ask Parliament to grant us powers for. We have, of course, learnt a great deal in the last few months as to the probable traffic and the future of this line, and we have used the knowledge derived from that information for the benefit of the concern, as far as it was capable of being used ; and we have come to the conclusion that it is desirable in your interests, and in the interests of the development of the traffic of this line, that power should be asked for that extension, and that it should be made. We have certain difficulties to deal with with regard to our City traffic at the present moment which this line (the extension) would help us to get over, and we want the middle of the day, as well as the early morning and evening, filled up by traffic for which we have abundant room, and for which all expense has been gone to. We don't think that can be entirely filled up by the district where the line now is. It must come from a more populous area. We have chosen a line and a district for the extension where the traffic is enormous, and which I feel satisfied, from our present knowledge, will prove a very remunerative undertaking itself. But, in addition to this, it will bring upon this line (the City and South London) exactly the traffic of which we are deficient. I think you should approve of this proposed extension. Of course, in approving the Bill you are not approving the carrying out of the works. If we obtain the Act we have to come to you for your consent to carrying out the works. It is merely a question of obtaining the Act if we can.

There are a few shares, as you will observe in the report, upon which the calls have not been paid. Some of these have since been claimed and the calls paid up, but certain others (15) are not likely to be paid up, and we have therefore no alternative but to declare them forfeited. We can do nothing with them until they are. I now beg to move the adoption of the report.

This was seconded by **Mr. Hubbard**.

Mr. J. Drake was glad to hear the line was now out of the range of experiment, and that the motive power was absolutely satisfactory, and complimented the engineer (Mr. Greathead) on the result. He would like to see the Clapham programme carried out. He also referred to the courtesy of the Secretary in answering questions when applied to for information. He thought the big scheme (Islington extension) required consideration. He did not want the small scheme to be swamped by anything of the gigantic proportions indicated.

Mr. Sydney Shepherd asked if it was possible to enlarge King William-street Station, so as to provide two sidings instead of one?

Mr. Tress Barry wanted to know whether the new locomotives to be ordered, could be made strong enough to draw more carriages than the present ones, or whether the latter could draw more weight than they did? He also asked for the cost of obtaining the proposed Act?

The **Chairman**, in replying, said he was afraid King William-street Station could not be enlarged. They could not lengthen it because of the Monument. They had the matter under consideration, were quite aware of the difficulties, and would be very glad if they could see their way to deal with that station. As it stood it was not capable of being greatly improved. That was one of the questions which were involved in the proposed Extension Bill. The service approach to the station was exceedingly bad, everyone having to pass over one of the worst crossings in the City, and that did them damage. They proposed, if they got the Extension Act, to give access to the station in the other part of King William-street, near Lombard-street, so as to avoid this crossing. In further reply to Mr. Shepherd, the **Chairman** said that the engineers were considering whether they could alter the platform so as to take four cars instead of three.

In reply to Mr. Barry, he said that in ordering their new engines they were considering the question of getting some additional power out of them. He did not anticipate that the Act for the extension would be very costly. They knew now all the opposition against it. He then put the motion, which was carried unanimously.

Resolutions were then passed re-electing Messrs. Walter Robinson and Sampson Hanbury directors, and the auditors Messrs. Turquand, Youngs, and Co., and forfeiting the shares mentioned above.

The extraordinary general meeting, which had been adjourned from the 3rd inst., was then held, to approve of the Bill for the Islington extension.

The **Chairman**, having made a few remarks of a similar character to those reported above, moved a resolution approving the Bill.

This was seconded by **Mr. Hubbard**.

Mr. Court, as the shareholder who was responsible for the adjournment of the previous meeting, stated that he had since conferred with the chairman and engineer, with whom he had gone fully into the matter. He now thought the scheme would be for their benefit, and supported the motion.

Mr. Broad opposed it.

Some discussion ensued, but eventually the motion was carried by a majority.

Mr. Broad demanded a poll, but on **Mr. Court** stating that he represented £80,000 of capital, and the **Chairman** remarking that they had 19,000 shares in their favour as against 2,000, Mr. Broad withdrew his demand.

Another resolution was passed giving the Directors power to take permissive powers in the Bill to make the extension a separate undertaking with separate capital.

A vote of thanks to the Chairman, proposed by **Mr. Godfrey** and seconded by **Mr. Broad**, closed the proceedings.

WESTMINSTER ELECTRIC SUPPLY CORPORATION.

The fourth ordinary general meeting of the shareholders of this Company was held at the offices, 32, Victoria-street, S.W., on Wednesday morning, the chairman, Lord Suffield, presiding.

The report stated that at the present time current was being supplied to the equivalent of about 12,000 lamps of 8 c.p., formal applications had been signed for about 17,000 more, and numerous enquiries continued to be made for the supply of current. The central station in Millbank-street had been running continuously day and night since November 13, 1890. Current was being supplied from this station throughout the whole length of Victoria-street, in various parts of Pimlico, and also to the Houses of Parliament. The work of laying the mains, like that of building, was seriously hampered by the severe weather. Notwithstanding this, since the work was started in February, 1890, mains had been laid along about 16 miles of roadway, and these included a total length of about 75 miles of "ways," into which about 40 miles of copper had been drawn.

The **Secretary** (Mr. Frank Iago), having read the notice convening the meeting, and the minutes of the last meeting,

The **Chairman** said : I presume the report (the gist of which is given above) will be taken as read. Although I am sorry to see so few shareholders present, still I may say that nothing can be more satisfactory in my opinion, and that of the Directors, than the affairs of the Company. This dreadful weather has no doubt stopped a great many from coming. I wish it had been otherwise, for I think what I have got to say will be acceptable to all. The report, which has been sent to each shareholder, will have already made you acquainted with the fact that the business of the Corporation is going on satisfactorily. Since our last general meeting, on the 5th of November, the Millbank-street central supply station has been completed, and current has been supplied therefrom continuously, day and night, in a most satisfactory manner. It frequently occurs that when a station is first opened some unexpected flaw, either in the machinery or in the mains, is brought to light, causing a serious breakdown, but I am happy to be able to inform you that this has not been our experience. Some slight irregularities in the light did occur for a few days, but this was before we got on to the batteries. Since then the light has been perfectly steady and satisfactory, notwithstanding the unusual demand throughout the whole of several days in consequence of fogs. You will hardly need to be told that fogs, however unpleasant they may be from a sanitary point of view, are, from an electrical point of view, a very different matter. We find that our heaviest loads come in during fogs, so that to us they are a source of profit instead of loss. I am glad to be able to inform you that since taking over the Millbank-street station from the builders we find that we have every reason to be satisfied with the work, and that the building is in every way suitable to our requirements. Here I may say that a very distinguished engineer, Sir Wm. Thomson, went to see that station, and—I am saying it on the authority of Sir Douglas Galton—he not only expressed himself perfectly satisfied, but I think he said it was one of the best he had ever seen. We have now sufficient plant and machinery erected there to supply all the lights likely to be required for that district during the next six months, and as the demand increases so shall we increase our machinery. I may here point out a great advantage which the Westminster district possesses over many others, which is, that within it are a number of offices, in addition to private houses and shops, and that these offices, requiring as they do to be lighted in the winter months through many hours each day before the chief part of the lighting of the private houses comes on, enable us to use our Millbank-street station to great advantage. We are at present supplying from the Millbank-street station some 9,000 lamps of 8 c.p. each. The cost of running at that station is now about £60 per week. This includes the cost of coal, water, stores, salaries, and wages. To this has to be added £90 per week for maintenance, depreciation of machinery and mains, establishment charges, rent and sinking fund on buildings, etc., making in all £150 per week. At the beginning of the month of January, the income per week for current supplied had already reached £150, which has now increased to £200, so that even in this early stage a profit is already being made. Of course, as the days lengthen, the same ratio will not be kept up ; nevertheless, it is to be noted that though the days have been lengthening of late, and the demand for current has, in the case of other companies which have been longer established, been falling off in consequence, our receipts have augmented. This is, of course, attributable to the increased number of lights which are daily being installed in the district, or, at any rate, partly so. The temporary station in Dacre-street, at the back of these offices, which is supplying the remainder of the lamps on circuit, has been of great service to us, in enabling us to supply current to the western portion of our district while the station at Eccleston-place was being built. In a few days the Eccleston-place station will be delivering current, and the temporary station will then be closed as soon as possible. I may tell you also, gentlemen, that I, together with a good many of the shareholders and the Directors, visited Eccleston-place as well as the other new station in Davies-street, and we were very much gratified with the progress that has been made. At our Davies-street station great progress has been made, and from there we expect to be supplying current by the end of next month. Had it not been for the severe and prolonged frost, which brought all building operations to a standstill for two months, current would have been supplied from both Eccleston-place and Davies-street before now. You will observe, by looking at the map on the walls, with what rapid strides the work of laying the mains has proceeded since you were last called together. There were then about 11 miles laid. To-day, notwithstanding interruptions, there are about 18 miles completed. This includes the principal streets throughout the district, in which there is the greatest demand. The others will be completed in the order in which the demand arises. I should mention that our consumption of coal already bears favourable comparison with that of the most economical of the older established companies, and that when the condensing plant, now on order, is erected, which, in the case of the Millbank-street station, will be in the course of the next two months, a still greater saving will be effected. Now, gentlemen, as to the question of capital and expenditure. You will see from the accounts sent with the report the expenditure under the different heads to December 31 last. Owing to the demand for light caused by the stoppage for about two months or more of the supply of the only other company having powers in the same district as ourselves, it was considered desirable by the Board to increase the amount of copper in the mains, especially in the Mayfair district, for which large numbers of applications have been received. This has largely increased the expenditure on mains, but, of course, will result in the earlier sharing of profits, as we shall be enabled to take on a much larger number of lights without delay. The Board are pleased to say that so far the whole of the works, whether of buildings—and I draw your particular attention to this because I think it is a most important point—mains, or plant, have been carried out well within the estimated cost, and that the total cost of the works to give enough current to supply the whole of our districts for some time to come, will not exceed the amount of capital asked for in the original prospectus of the Company—viz., £300,000. The amount actually subscribed was £214,765, in 42,953 shares of £5 each, leaving a balance of £85,235, in 17,047 shares of £5 each. To provide for the extra cost of laying mains, completing the present work in hand, and making provision for any extra work the Board may consider it desirable to enter upon, they suggest to the shareholders that the Directors be empowered, at their discretion, to issue all or any part of the 17,047 shares, the balance remaining unissued. They feel justified in asking them (the shareholders) to increase their holdings, as there is no doubt of the future financial success of the undertaking. Well, gentlemen, you don't know me perhaps, and I don't know how you should, but I tell you that I would not make this statement if I did not believe it to be absolutely true. The Directors have also passed a resolution to issue, if required, £100,000 debentures at 5 per cent. interest, to run for a term of 10 years, but not to a greater extent than an amount of one-third of the share capital for the time being.

I may now say, and I think it is gratifying, that the calls on the shares have been very well paid up. Out of all the calls that have been made, there remains only a small balance to be paid up, which I have no doubt will be forthcoming very shortly.

I now beg to move the adoption of the report and accounts for the past year. If any shareholder has any question to ask, we shall be pleased to give him every information in our power; and I believe that we can give him all the information that can be required.

Mr. Boulnois, M.P., seconded the resolution, and, referring to the working of the Board, said that he could assure the shareholders that though they had many discussions, they had no differences, and since he had had the honour of a seat at it, the proceedings had been conducted with the utmost unanimity. As to the staff, he was sure he spoke the thoughts of his co-Directors when he said that it was impossible that any staff could exhibit more ability, more zeal, and more loyalty than theirs from the highest to the lowest. They were especially happy in having so able an engineer as Prof. Kennedy, and equally happy in having a manager like Capt. Bax, and an active secretary like Mr. Iago. He thought there was a very great future in store for that Company if the shareholders would have confidence in the Directors.

Mr. Wm. Cooper asked as to the item on the credit side of the balance-sheet, £3,957. 2s. 8d., "expenditure applicable to future business," and to what it referred. Was it not properly chargeable to capital, or whether it should be in the revenue account?

A **Director** explained that it referred to work done which would be remunerative in future years, such as getting customers, travelling expenses, advertising, and organising the staff. It could not be placed to capital account, because it was not a capital charge. It would be written off in future years, but they had not resolved at what rate. At a future meeting an account would be given of it.

Mr. Rogers Wallis asked if any steps had been taken to get a provisional order conferring greater facilities in the northern portion of St. Margaret's parish, and as to the issue of debentures.

The **Chairman** answered the first question in the affirmative, and as to the debentures, said they were in no immediate necessity, and did not intend to issue them at once. They issued them in accordance with the articles of association, which gave them power so to do.

Mr. Brown Martin pointed out there was a very great advantage in issuing debentures at 4 or 5 per cent., instead of 7 per cent., which they might anticipate having to pay on fresh capital, so that they saved 2 per cent. for the benefit of the shareholders.

Prof. Kennedy, in answer to a question, said that at present they were paying their way with the earnings from the Millbank station, and the comparatively small number of lights supplied from there.

The **Chairman** then put the resolution adopting the report and accounts, which was carried unanimously.

Resolutions were next passed authorising the Directors to issue the remaining shares, and re-electing the Auditors, Messrs. Cooper Bros. and Co.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

BELL'S ASBESTOS COMPANY.

The third ordinary general meeting of this Company was held at the Cannon-street Hotel on Monday afternoon, Mr. John Bell, chairman, presiding.

The **Secretary** having read the notice convening the meeting,

The **Chairman** said: Gentlemen, as the report and accounts have been in your hands for some time, I will consider them as read, and will just make some observations upon the leading items in the accounts. The bills receivable, stated at £10,273. 12s. 4d. as on December 31, have about three-fourths of them fallen due, and, as a matter of course, have been paid. I say as a matter of course, because they would not occupy their position in the accounts next to the cash—they would not be allowed by the Auditors to do so—if there had been any reasonable doubt with regard to them. All of you who have any experience of an audit by Messrs. Cooper Bros. and Co. know perfectly well that all such things as allowance for bad and doubtful debts, writing off from plant or stock, and so forth, are always strictly and severely attended to. A very full allowance has been made for bad and doubtful debts, and, therefore, the £31,723 is as good as the bills to which I have just referred. The stock has grown during the last year from two causes. We made some purchases in advance of our requirements, which we considered to be of a very advantageous nature for the Company, and the decline in the trade mentioned in the report has caused an accumulation of stock; but everything that is old and obsolete—and there is very little of that—has been put down at nil. You may take it that the general principle is that the stock is valued simply at cost price. There never was a sounder figure in the assets of any Company than this £51,599 in the balance-sheet placed before you to-day. With reference to buildings, plant, and machinery, fittings, fixtures, and so forth, you will recollect that when this business was taken over by this Company it was stipulated that the plant and machinery should be purchased at the price at which it stood in the books of John Bell and Sons, subject to an independent valuation, and an independent valuer estimated them at double the amount, or thereabouts, at which they were taken over by the Company. That was due to the severe writing down that had taken place during many previous years, and that same severity in writing down has been continued by the Directors of this Company as a going concern, and therefore plant, machinery, etc., £6,837, are a very good asset. The asbestos estates in Canada were purchased by the Company from John Bell and Sons at the exact price at which that firm had acquired them, and that fact, as it was a magnificent purchase they (the Company) had made, was part of the consideration for the goodwill paid to that firm. The mines at the present day are worth vastly more than the sum paid for them and the total goodwill put together.

The two other items (expenditure on account of 1891 and expenditure on new buildings) are so small they are not worth talking about. The £40,000 premium on new shares transferred is placed in the profit and loss account, not for the purpose of swelling that account, but because the Directors had no option in the matter. It was laid down in the articles of association that this premium must be especially placed in the profit and loss account, and that is the reason it is so placed, and for no other cause. I have never considered it my duty to enter into newspaper discussions about the affairs of this Company; I have always considered it to be the reverse of my duty, and therefore I have not replied to various criticisms made at different times. I have felt rather inclined to let calumny die out. But in deference to the wishes of many of our best friends, and especially of many of our best customers, I must say some very plain things indeed upon what lies at the bottom of the decline in our trade during the past year. A year ago it was my duty to lay before you the system on which we follow the very common practice of giving gratuities to those who have the practical handling of the goods we sell. I told you, in words which could not be honestly misunderstood, that we had never given a penny to any man to cover inferior quality or shortness of weight or measurement; that in no sense or degree had we ever corrupted any man by a bribe or inducement to do wrong. You gave your sanction to our action in this matter, and very soon after the First Lord of the Admiralty stated in the House of Commons, in reply to a question, that our name had, on this account, been removed from the list of contractors to the Admiralty. Had we been asked whether we had anything to say for ourselves, we should have been able to reply that during our 10 years' dealing with the Admiralty we had never given a penny to any servant of that department, that no mark stood against us for failure of our material under any circumstances, and that we had never been wanting in weight or measurement to the extent of a single gramme or millimetre. We could have added that the most important forms in which asbestos is used in the navy had been first designed and worked out to practical use by us, at the expenditure of time, labour, and money. But no such question was put to us, and, as was not unnatural, the belief became general in the public mind that such a denunciation in the most public place in the world, in language of marked severity, by a person of high position and responsibility, was the result of an official investigation by means of which we had been convicted of corrupting public servants. It suited, and still suits the purpose of previously very unsuccessful trade rivals to propagate and foment, by many devices, the idea that we are not as honourable traders as they. A certain section of the so-called financial press have been useful allies of our trade rivals in furnishing specially dished-up articles and paragraphs which zealous commercial travellers have brought under notice in thousands of places where, but for their efforts, such papers would never have been heard of. Set going by so powerful an authority as the First Lord of the Admiralty, the crusade against us became fashionable, and gained strength as it proceeded. The sowing of wicked calumny broadcast became easy of accomplishment, and has been fortunate in achieving such success as all efforts on the part of its chief promoters to rival us in the excellence of our manufactures and in the success of our trade had utterly failed to attain. We have to own to-day that what fair competition could not do, persistent detraction in private and in public has accomplished, the result being that in the last year we have lost a large amount of trade. I shall endeavour to show you, not by dry reasoning on abstract principles, but by an appeal to your own every-day experience, that to point to this Company as something out of the common, and to make up against it a charge of bribery and corruption, is outrageously unjust; and I hope to leave on your minds a conviction that having stood so well, as we have stood, the first heat of the onslaught, we shall eventually come out of this contest chastened, but not vanquished, and we shall regain our former hold of the first position in our trade, which, though it has been shaken by the events of the past year, no one has yet been able to wrest from us. Thus, I shall hope to justify the belief expressed in the report, that the decline in our trade will not be permanent. I have declared to you, but let me, by repetition, emphasise the declaration, that we have never given a penny to any man to cover defect of quality, or of short weight or measurement. No man has ever ventured to say that we have, though there are those who would be glad to be able to say so. True, we bow to the rule of "backsheesh," as it is allowed to prevail in all countries and among all sorts and conditions of men. It is not enough to say none are too low for it: we must also say none are raised above it. Bribery and corruption are not so allowed to prevail; the humblest despise them as sincerly as the highest. But gratuity-giving in an infinite variety of forms, though nowhere commended, is everywhere practised without reproach to him who gives or to him who receives. Take an instance or two. A railway porter secures for you, to the exclusion of some-one else, a comfortable corner seat and gets sixpence; but the man opposite to you has given somebody half-a-crown so that he may travel first-class at third-class fare. You have given an unlawful gratuity which cannot be defended on abstract principle; but nobody accuses you of bribery and corruption, as they rightly do the fellow opposite to you. The good sportsman, respected merchant, esteemed director of the great railway and steamship companies—even a noble lord (if he be not one of the Admiralty)—when he sells a horse gives a sovereign—sometimes more—to the groom of the buyer. Why does he give this unlawful gratuity if he honestly believes the animal is all that he has described him to be? Why, he follows a custom, and he feels himself safer in doing so than he would if he kept the money in his own pocket. Who dreams of accusing him of bribery and corruption? In the shooting season the moors of Scotland are crowded with directors, managers, superintendents, and all sorts of people who can influence or give out orders. They are not on the moors at their own expense. Luxurious yachts career over the seas filled with such men, also not at their own expense. Here is a vast use of what, strictly speaking, is undue influence to gain a trade object. But who calls it bribery and corruption? Who ever proposes to strike his host's name from a list of contractors because of it? Yet, if I give a weekly-wage earning mechanic a couple of sovereigns to help him to afford his family a summer holiday at Blackpool or Margate, up go your eyes and out comes the Pecksniffian howl against bribery and corruption. Your solicitor—I know my friend Mr. Stibbard has always been one of the exceptions which prove the rule—gets a commission when he influences you to insure your life or property in a particular office. Some bankers get a return of brokerage when they employ a stockbroker to invest your funds. Some great railway companies tip forwarding clerks to secure a preference of goods traffic for their lines. Makers of steam engines propitiate the man who is to drive a new engine just laid down. Even these remarks of mine will, in certain places, be favourably commented on, or the reverse, according as we are liberal or otherwise in purchasing copies of certain journals for distribution. One more example in a region where one treads with reverential care—the region of high justice. When commercial companies go into liquidation, it often happens that an eminent public accountant is appointed by the court to carry on the business, and such official manager finds that he has to fall in with this practice of gratuity-giving, or the business would come to a deadlock. He applies for and obtains the sanction of a judge. This, of course, could not be if all gratuity-giving for the furtherance of business was bribery and corruption. I might occupy much more of your time in pointing out scores of facts in your own every-day experience, showing "backsheesh," which is universally admitted to differ from bribery and corruption, is used throughout all grades of society to further the ends men have in view. But why dwell on what is in every man's conscience? My point is not that gratuity-giving is right, but that Bell's Asbestos Company is not different to other men, that we are in the common swim, and that this fact must come to be realised as a fact. And thus men will see that we are more sinned against than sinning, and that as the public judgment in regard to us regains its balance, we shall gain the trade that has been, without due cause, withdrawn from us. Some of you shareholders in this company are employers of labour, and users of steam power. If you wish to do away with this system of gratuity-giving, you must do something more effectual to the purpose than transferring your account from us to some other concern. You must go below the surface, and recognise that this matter has its root in the never-ending struggle between capital and labour, that it is an outcome of the determination of every man to use any power he possesses to get something beyond the bare necessaries of life, and if you don't like the form of it, set yourselves to provide a substitute for it. We (the Directors) are anxious to find this substitute, and we are ready to co-operate with any set of employers who will honestly deal with this question on the human, not the Pharisaic principle. Now, gentlemen, shareholders in this Company, do your part. Let no man in your presence venture to accuse this Company of bribery and corruption. Tear the mask away wherever you meet it, and assert your Company as better able to face the world than any of its traducers. Do this boldly and constantly, and you will soon have your dividends over 20 per cent. again. Let us now pass on to the Canadian properties of the Company. The use of asbestos in the manufacture of steam packing and as a non-conductor in various forms has greatly grown, and the consumption has completely caught up the supply obtainable from such mines as are in efficient working at Thetford and some less important outside places, but no new application of the material calling for large quantities of it has come to light. For the present trade the mines now in work can furnish what is required, and the remunerative prices which have now become established will sufficiently stimulate production at those mines to meet the growing demand until some new use of asbestos calls for larger quantities than can be supplied from the present sources. We have not abandoned, as certain busybodies have alleged, our Bellmina and Hayden estates. We have them in reserve, and when the growth of our trade requires us to break into new ground your Directors will not hesitate to do the work. Meanwhile we shall be content to make money quietly and safely at Thetford. We have made very important forward sales of the estimated surplus of crude asbestos over our own manufacturing requirements during the present year. I am under engagement to the buyers not to mention quantities or prices, but I may venture to state that these sales will, with ordinary good fortune in the working, give us a very much larger profit than has hitherto been obtained from ours or any asbestos mines. It is true the effect of these sales will be somewhat watered by previous contracts at much lower prices, the fulfilment of which to some extent runs into the present year. It is also probable that the fact of there being a quantity deliverable by us at comparatively low prices has militated against our obtaining so high a value as we should otherwise have secured. I am, however, very sure that our policy of dealing freely at the prices obtainable in the natural course of our trade is the right policy, and we have done so well on these present contracts that regret is out of place. The income now being derived from the Thetford mine places the value of that estate at a higher sum than was paid to the Company for all the properties and goodwill of the business taken over. We are very desirous of strengthening the Board by the addition of a member possessing the necessary experience and influence to make a real acquisition to the Company. The kind of man we want is much occupied and difficult to get. We want a man whose knowledge, experience, and influence count for something among steam users, and a man who will be satisfactory to our altered list of shareholders. We are in very full communication with a gentleman of first-rate commercial standing, and of the sort I have just described, and I hope that we shall soon be able to make an announcement on this subject, which cannot fail to be satisfactory to the shareholders. In this matter the Directors have given special attention to the change which has taken place in our list of shareholders. Our shares have now passed out of the few hands in which they were held in large blocks, and, instead of a trifle over 300 shareholders to whom we allotted, we have now 900 members or over. This altered condition of our share-list may, and probably will, bring about important changes. One beneficial change that we look for is that, as small shareholders take more direct interest in their investments than great ones, therefore the spread of our stock into many hands will strengthen our Company in many ways and advance its trade. I beg leave to move "That the report of the Board of Directors and the Auditors, and the financial statement, submitted to this meeting, be, and the same are hereby, approved, adopted, and confirmed."

This was seconded by **Mr. T. B. Lightfoot.**

Mr. Atkinson hereupon rose and put a series of 12 questions, which had been printed and circulated in the room.

Mr. Hirsch asked if Mr. Atkinson was a shareholder, and after some discussion it came out that he was not on the register, but had had one share given him by a friend who, he stated, had lost several hundred pounds over the Company. The Chairman was thereupon requested not to answer, and Mr. Atkinson was asked to remove himself. Which, however, he did not do.

Mr. Ridley (a shareholder) then rose, and said he would put the questions, and Mr. Hirsch again urged the Chairman not to answer them, stigmatising them as impertinent.

The **Chairman**, however, said there was no difficulty in answering the questions, and proceeded to show that there was practically no foundation for any of them. To the major portion he gave a direct negative, only refusing to answer those concerning the internal management of the Company. He then put the resolution, which was carried unanimously, that is, if we exclude Mr. Atkinson as a dissentient.

Resolutions were then passed approving a dividend of 5s. per share free of income tax, making, with the interim dividend, a total of 15 per cent. for the year; re-electing Mr. T. B. Lightfoot as a director; and Messrs. Cooper Bros. and Co. as auditors.

A hearty vote of thanks was accorded to the Chairman and Board on the proposition of **Colonel Wortham**, seconded by **Mr. Hirsch**.

MANCHESTER EDISON-SWAN COMPANY, LIMITED.

An extraordinary general meeting of this Company was held on Monday at the Victoria Hotel, Manchester, for the purpose of considering the advisability of obtaining additional capital by the issue of debentures or otherwise.

Mr. Vernon K. Armitage, chairman of the Company, who presided, explained that the meeting was called in accordance with a promise made by the Directors that the shareholders would be consulted before any scheme involving any considerable expenditure of money was entered upon. As he had informed the shareholders on a previous occasion, there had recently been a very marked diminution in the demand for small installations of the electric light, and the Directors thought that in view of the large number of provisional orders which had been recently granted to local boards and corporations, it was desirable that they should have the ability, if they had the opportunity, to do such large work as the carrying out of such provisional orders would involve. The Directors felt that if they were placed in a position to raise such money as they might consider necessary, there was a future for the Company, especially in a place like Manchester, where a provisional order for electric lighting had been obtained. By the articles of association the Directors had full power to raise what money was required on debenture or by call, but in accordance with the promise they had made they desired to secure the assent of the shareholders before going forward. With reference to the general position of the Company, he added that he thought there was not the smallest doubt that for the current year they would make 7 or 8 per cent. on the capital that had been called up.

In reply to a question by Mr. F. B. Ross, the **Chairman** stated that it was not yet known what amount it might be necessary to raise. That would depend altogether on the extent to which they were entrusted with orders.

Some discussion followed, at the close of which, without any formal resolution being passed, it was left to the Directors to obtain such additional capital as they consider necessary.

LIVERPOOL ELECTRIC SUPPLY COMPANY.

The annual meeting of this Company was held on Tuesday in Liverpool, Mr. Arthur Hill Holme, chairman, presiding.

In their annual statement of accounts the Directors reported that the amount of net profit available for dividend was £4,878. 9s. 6d., and out of this sum they recommended a dividend of 3½ per cent., which would absorb £4,074. The expenditure on capital account during the year had been £54,019. The number of lamps supplied from the Company's stations on January 1, 1890, was 6,700, and on January 1 of this year 11,750. It was anticipated that during the present year there would be still greater progress in this direction, with corresponding advantage as regarded profits. The Directors had applied for parliamentary powers to extend the present area of supply to London-road, Prince's-road, Prince's-park, and Sefton-park. The assent of the Toxteth Local Board had been given, but the Liverpool Corporation withheld their assent, as the Directors were unable to accept the conditions which were sought to be introduced into the draft order.

The **Chairman**, in moving the adoption of the report and statement of accounts, remarked that the Company had made a considerable addition to their business during the past year. They had also adopted all the latest improvements in electric lighting, and everything possible had been done to secure a good and steady light. In this they had succeeded, with the result that they were now giving their customers a supply of electricity second to none in England. They had increased their number of fixed lamps from 6,700 to 13,074, although they had engines of sufficient power to supply 25,000 lamps. The Directors had written off a sum of 3 per cent. for depreciation on all underground mains laid since the commencement of the Company, including those which were not yet in use. Serious thought had been expended on a project for extending the business of the Company, and, as stated in the report, they were contemplating carrying the electricity to London-road and to Prince's and Sefton Parks. They had had considerable difficulty with the Corporation as to a provisional order for London-road, but permission for the other areas had been readily granted by the Toxteth Local Board. The Directors saw the importance of taking the light to London-road, for there was a demand for it, and they would have difficulty in extending their business if an opposition company occupied so important a position as London-road. The necessity of making a call upon the shareholders would probably not occur before January next, and then the call, it was anticipated, would not exceed 10s. per share.

Sir David Radcliffe seconded the Chairman's motion, which was unanimously agreed to.

Messrs. Von Sobbe and Samuel H. Holme were then re-elected as Directors; and the remuneration to the Directors was, on the proposal of Mr. Charles Birchall, increased from 150 to 250 guineas.

HASTINGS ELECTRIC LIGHT COMPANY.

The annual general meeting was held recently at Hastings, Mr. H. M. Baker, chairman, presiding.

The Company has made a net profit of £543. 13s. 6d. (including a balance of £97. 0s. 11d. brought forward from last account) for the nine months ending December 31. A dividend of 5 per cent. has been declared. To provide for supplying incandescent lights under their order, the Company have issued £2,000 worth of 5 per cent. debentures. They have received more applications for lights than they can fulfil until they have the new machinery. The Directors not having hitherto received any remuneration, a resolution was carried voting them £200.

COMPANIES' REPORTS.

TAUNTON ELECTRIC LIGHTING COMPANY.

The following report of the Directors was presented at the shareholders' meeting on Wednesday:

Your Directors herewith present the fourth annual report of the Company, together with the audited balance-sheet. The number of shares allotted is 2,556, on which the sum of £12,780 has been received. During the year the new buildings in St. James's-street, referred to in the last annual report, have been completed. These buildings, with the new machinery and plant laid down, make the works of the Company quite a model depot. But the completion of these works took a much longer time than had been anticipated; and during the early part of the year there was the expense, for a time, of running two works, in consequence of which the cost of coal and other items was very much higher than would have been the case under normal conditions. Further than this, the work of the construction of the new circuits in the town was much delayed in consequence of the stringent requirements of the Board of Trade; thus retarding the whole business of the Company for several months, during the most important part of the year, for constructive work. Under all these exceptionally adverse circumstances, it will hardly be matter for surprise that the accounts show a deficit on the year's working of £438. 17s. 5d.; but now that the works are in good order, and the business of the Company constantly increasing, there is every reason to believe that the next year's working will show a different result. Towards the close of the year it was found necessary to obtain more capital than the issue of ordinary shares secured, and your Directors therefore determined to issue £5,000 debentures, such sum to include the previous issue of £3,000; and they confidently appeal to the present shareholders to come forward and take up this issue of £5,000 debentures. Since the issue of the last annual report, Mr. John Withycombe has resigned his seat on the Board of Directors, in consequence of his having gone to reside at Minehead. Your Directors appointed Mr. Arthur A. Chapman to fill the vacancy thus created, and they ask the shareholders to confirm the appointment. The Directors who retire by rotation are Messrs. Alfred Lewis, H. G. Massingham, and A. Stevens; the two former offer themselves for re-election. The auditor, Mr. Albert Goodman, retires; but being eligible, offers himself for re-election.

ST. JAMES AND PALL MALL ELECTRIC LIGHT COMPANY, LIMITED.

Directors: Eustace J. A. Balfour, Esq., chairman; Latimer Clark, Esq., F.R.S.; Egerton H. Clarke, Esq.; H. Woodburn Kirby, Esq.; Sir John H. Morris, K.C.S.I.; Charles Showell, Esq. General manager and secretary, James Strick. Chief engineer, S. T. Dobson, Assoc.M.Inst.C.E., M.Inst.E.E. Auditors, Messrs. Deloitte, Dever, Griffiths, and Co. Solicitor, Sydney Morse.

Report of the Directors and statement of accounts for the year ending 31st December, 1890, to be presented to the shareholders at the meeting to be held at Winchester House, Old Broad-street, E.C., on Monday, March 2, at three o'clock.

The Directors in submitting their annual report for 1890, with accounts as certified by the Company's Auditors, congratulate the shareholders on the satisfactory progress made by the Company during the past year. At the commencement of the period under review, the number of lights connected amounted to the equivalent of about 4,460 8-c.p. lamps. This number gradually increased up to the 30th September, when the number of lamps connected amounted to about 12,150. In the last quarter of the year remarkable progress was made, and on the 31st December the lamps connected amounted to about 26,500, and this total has since been increased to about 30,000. On the 23rd July last, a prospectus was issued inviting subscriptions at par for 3,670 ordinary shares. All these shares have been taken up, the bulk of them being subscribed for by the Directors and their friends, the shareholders subscribing for a very small number. On the 9th January, the balance of the original issue of shares—viz., 980—was allotted. These subscriptions have enabled the Board practically to complete the existing station, which is now in every way working satisfactorily. Of the £50,000 debentures, which, as will be seen from the accounts, were outstanding on the 31st December, £43,000 have since been converted into ordinary shares under the powers contained in the articles. On the conversion of the balance of £7,000 of the debentures, the capital account of the Company would stand as follows :

19,980 ordinary shares of £5	£99,900
100 founders ,, £1	100
Making a total of	£100,000

The conversion of these debentures places the Company in a position to at once raise moneys for the purposes of the northern station, which the Company has to erect to satisfy the requirements of the district covered by the provisional order granted by the Board of Trade, and approved by Parliament during its last session. The question of the amount of damages payable by the contractors for delay was referred by consent to the arbitration of Mr. J. Fletcher Moulton, Q.C., who awarded the sum of £1,806. 11s. 6d. to the Company for loss of income. The Directors being of opinion that this sum represents the equivalent of depreciation up to the 31st of December, 1890 (a large part of the machinery having been in work for but a short period), have written this amount off capital expenditure. By reference to paragraph 2 of this report it will be seen that the station has practically been at work for three months only in 1890, and that the dividend has been earned during that period. The Directors have, therefore, after consultation with the Company's Auditors, charged £963. 3s. 1d., being one moiety of Directors' fees and management salaries for the year, to capital expenditure. On Statement III. it will be seen that the account of capital is charged with £65,981. 11s. 9d. as expended to December 31st, 1889. The balance-sheet at that date displays that this sum is made up of capital and general expenditure from which is deducted a small sum received for current supplied, etc. During the first six months of the year the Company's revenue showed a debit of £183. 7s. 11d. During the last six months the profit amounted to £5,161. 8s. 8d., which, after deduction of the debit referred to, leaves a balance of £4,978. 0s. 9d. to be dealt with. Of this sum £2,412. 8s. has been provided for payment of interest, and out of the balance of £2,565. 12s. 9d., the Directors recommend a dividend of 5s. per share, free of income tax, on the 9,000 ordinary shares in existence on the 31st December, 1890, absorbing £2,250, leaving a balance of £315. 12s. 9d. to carry forward. The experience gained since September has satisfied the Directors that the shareholders possess a very valuable property, which will yield a large steadily increasing income on their investment. The Directors regret the loss of their esteemed colleague, Mr. James Hemmerde, who died in the autumn of last year; they have, under article 84, appointed Mr. Egerton H. Clarke to a seat on the Board in his stead. Two of the Directors—namely, Mr. Eustace J. A. Balfour, the chairman, and Mr. Latimer Clark, F.R.S.—retire under clause 79 of the articles of association, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and, being eligible, offer themselves for re-election. Referring to the notice of the extraordinary general meeting on page 2, should the shareholders adopt the suggestion of the Directors to increase the capital of the Company by the creation of 7 per cent. preference shares, it is the intention of the Directors to offer 10,000 of such shares to shareholders now on the register in the proportion of one preference share to every two ordinary shares. It being necessary to alter the articles of association to entitle this Company's shares to a quotation on the Stock Exchange, the Directors have taken the opportunity to remodel them.

No. I.—STATEMENT OF SHARE CAPITAL ON 31ST DECEMBER, 1890.

Description of Capital.	Authorised by.	Number of Shares Issued.	Nominal Amount of Share.	Called up per Share.	Total paid up.	Issued, not paid up.	Remaining unissued.	Total Amount Authorised.
			£	£	£	£	Shares	£
£99,900, divided into 19,980 Ordinary Shares of £5 each.	Memorandum of Association	9,000	5	5	44,880	120	10,980	99,900
£100, divided into 100 Founders' Shares of £1 each.	Ditto	100	1	1	100	Nil	Nil	100
		9,100			44,980	120	10,980	100,000

No. II.—STATEMENT OF LOAN CAPITAL ON 31ST DECEMBER, 1890.

Description of Loan.	Amount Borrowed.		Remaining Borrowing Powers.	Total Amount of Borrowing Powers.
	At 6 per cent.	Total.		
	£	£		
Six per Cent. Mortgage Debentures.	50,000	50,000	Nil	One-half the nominal capital of the Company for the time being.

Total Share Capital paid up, *see* No. I................	£44,980
Total Loan Capital borrowed, *see* No. II..............	50,000
Total Capital received..	£94,980

No. III.—CAPITAL ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Dr.			£ s. d.
Expenditure to 31st December, 1889, per last account, including preliminary expenses, see paragraph 8 of Directors' report			65,981 11 9
Buildings and paving......................		£124 18 4	
Machinery and plant		10,876 8 6	
Accumulators		1,543 10 5	
Mains, including cost of laying		8,171 8 11	
Meters fixed on installations........ ...		1,322 11 0	
Switches do. do.		509 19 6	
Stores and labour used on do.		1,172 19 7	
Electrical instruments		166 13 1	
Cost of license, provisional order, etc.		359 10 1	
Sinking artesian well		424 2 6	
Proportion of Directors' fees and management salaries, chargeable to capital expenditure in 1890, see paragraph 8 of Directors' report ...		963 3 1	
Office and other furniture and fittings, 1889	£247 4 1		
Ditto, ditto, 1890	262 17 4		
		510 1 5	
		26,145 6 5	
Less £1,806. 11s. 6d. recovered from the contractors under an award of Mr. Moulton, Q.C., as being loss of revenue for delay (this amount represents the equivalent of depreciation, see Directors' report, paragraph 7)		1,806 11 6	
			24,338 14 11
			90,320 6 8
Balance of capital account			4,659 13 4
			£94,980 0 0

Cr.	£ s. d.	£ s. d.
Ordinary shares, 9,000 of £5 each ...	45,000 0 0	
Less calls in arrear (paid in 1891) ...	120 0 0	
		44,880 0 0
Founders' shares, 100 of £1 each.........		100 0 0
6 per cent. mortgage debentures.......		50,000 0 0
		£94,980 0 0

No. IV.—REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

A.—To Generation and Distribution of Electricity.

Dr.		£ s. d.	£ s. d.
Coal and other fuel, including dues, carriage, etc.		2,617 0 4	
Oil, waste, and engine-room stores ...		591 19 8	
Salaries of engineers and officers		328 6 8	
Wages at generating and distributing station		1,624 0 7	
Repairs and maintenance, as follows:			
1. Buildings	£16 2 5		
2. Engine and boiler......	47 17 0		
3. Accumulators	0 5 0		
4. Lamps (at station) ..	38 7 11		
		102 12 4	
Miscellaneous expenses.....................		30 7 10	
			5,294 7 5

B.—To Rent, Rates and Taxes.

Rents payable..	227 15 0	
Rates and taxes	294 12 11	
		522 7 11

C.—To Proportion of Management Expenses.

Directors' remuneration (balance, after charging £500 to capital)........... ...	500 0 0	
Salaries of secretary, engineer, clerks, etc. (balance after charging £463. 3s. 1d. to capital)	497 6 5	
Stationery, printing and advertising .	291 7 7	
General establishment charges	171 10 1	
Auditors	26 5 0	
		1,486 9 1

D.—To Law and Parliamentary Charges.

Law expenses	214 9 2

E.—To Special Charges.

Insurance	30 3 7
Total expenditure	£7,547 17 2
Balance carried to net revenue account	4,978 0 9
	£12,525 17 11

Cr.	£ s. d.
Sale of current.............................	12,282 4 7
Rental of meters on consumers' premises...............	126 14 2
Rents receivable	100 0 0
Transfer fees	4 9 6
Discount on purchase...	12 9 8
	£12,525 17 11

No. V. — Net Revenue Account for the Year ending 31st December, 1890.

Dr.				£	s.	d.
Interest on debentures	£2,363	11	7			
Interest on temporary loans and bills payable	48	16	5			
				2,412	8	0
Balance, being net profits applicable to dividends on shares				2,565	12	9
				£4,978	0	9

Cr.	£	s.	d.
By balance brought from revenue account (No. IV.)	4,978	0	9
	£4,978	0	9

No. VI.—General Balance-sheet, 31st December, 1890.

Dr. Capital Account.	£	s.	d.
Amount received as per account No. III	94,980	0	0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc.	4,744	4	0
Sundry creditors on open accounts	1,342	9	10
Bills payable	1,746	1	0
Net revenue account— Balance at credit thereof	2,565	12	9
	£105,378	7	7

Cr. Capital Account.				£	s.	d.
Amount expended for works, as per account No. III				90,320	6	8
Stores on hand—						
Coal	£427	10	0			
Oil, waste, etc.	47	10	2			
Meters	172	6	0			
Switches	29	12	0			
General	1,151	6	8			
				1,828	4	10
Sundry debtors for current supplied				6,576	1	0
Other debtors				79	4	8
Cash at bankers (Lloyd's Bank, Limited).	£6,553	3	8			
Cash in hand	21	6	9			
				6,574	10	5
				£105,378	7	7

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

The twenty-seventh annual report of the Directors states that the accounts for the year show a net profit of £113,681. 4s. 8d., after charging the interest on the debentures. To this sum must be added £37,483. 7s. 3d. brought forward from last year, making a total of £151,164. 11s. 11d. From this amount is deducted the interim dividend of 5 per cent., paid July 15, 1890, amounting to £22,410, leaving £128,754. 11s. 11d. to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., leaving £61,524. 11s. 11d. to be carried forward to the next account.

PROVISIONAL PATENTS, 1891.

February 16.

2798. **Improvements in solutions and salts for electro-deposition and other purposes** Henry Joseph Altman, 44, Bolton-road, St. John's Wood, London.

February 17.

2834. **Automatically recording the value of shots upon targets by electric apparatus.** William Hallam Elton, 19, Belgrave-terrace, Exmouth.

2840. **An improved method of heating curling tongs or irons by electricity.** Arthur Henry Watson and Frank Emanuel Antonini, 4, Pall-mall, London.

2862. **Improvements in electric fire engines, also applicable to other electrically propelled vehicles.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

2866. **Improvements in electrical measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Weston, United States.) (Complete specification.)

2876. **Improvements in the application of electricity to various useful purposes.** Edward Robert Dale, 8, Quality-court, London.

2902. **An improvement in electric locomotives.** George Sylvester Grimston and Ernest Wilson, 28, Southampton-buildings, London.

February 18.

2986. **Improvements in apparatus actuated by electricity for stirring, and turning over malt and grain.** Edmund Edwards, 35, Southampton-buildings, London. (Julius Sandt and Heinrich Sturm, Germany.) (Complete specification.)

February 19.

2999. **Improvements in electric arc lamps.** Hubert Hallam Bigland and John Burns, 6, Lord-street, Liverpool.

3003. **Improvements in element for electric battery.** Ernest William Mayer, 71, Great Portland-street, London.

3030. **Improvements in propelling vehicles by means of electric motors.** Michael Radcliffe Ward, 12, Dacre-street, Westminster, London.

3049. **Improved circuit controller and alarm.** Claude Kennedy Mills, 23, Southampton-buildings, London. (Charles Morris Woolcott and Albert Edward Wilmont, United States.)

February 20.

3127. **Apparatus for automatically indicating loss or diminution of current in electric circuits.** William Cruyt, 433, Strand, London.

February 21.

3170. **Improvements in the manufacture of Leclanche cells.** Dan Rylands, Stairfoot, near Barnsley.

3191. **Improvements in the transmission of alternating differential phase currents.** Michael von Dolivo-Dobrowolsky and the Company Allgemeine Elektricitäts Gesellschaft, 47, Lincoln's-inn-fields, London. (Complete specification.)

3198. **Improvements in galvanic batteries.** Flavien Poudroux, 35, Southampton-buildings, London.

3199. **An improvement in electrical switches.** Harry Christie Harold and Robert Jenkins, 28, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1890.

1897. **Composition for electrical insulating, etc.** Fahrig. 6d.
2876. **Safety devices for electric currents, etc.** Walter. 8d.
2945. **Electric secondary cells.** Laurent-Cèly and Timmis. 11d.
3839. **Cable telegraphy.** Delany. 8d.
3960. **Galvanic medical appliance.** Wood. 6d.
3967. **Secondary battery elements.** Stevenson. 6d.
4821. **Insulated electric conductors.** Obach. 4d.
4991. **Electric arc lamps.** Gay and Hammond. 8d.
15455. **Welding metals electrically.** Thompson (Coffin). 6d.
18190. **Multiplex telegraphy.** Gisborne (Keeley). 8d.
19272. **Electric soldering irons.** Carpenter. 8d.
20111. **Electrolytic decomposition of metallic salts.** Lake (Roberts and another). 8d.
20424 **Alternating-current motors.** Von Dolivo-Dobrowolsky and others. 6d.
20425. **Alternating-current motors.** Von Dolivo-Dobrowolsky and others. 6d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended February 20 amounted to £6,114.

City and South London Railway.—The receipts of this Company for the week ended February 21 amounted to £718.

Western Counties Telephone Company.—The Company have declared a dividend upon their preference shares at the rate of 6 per cent. per annum for the half-year ended December 31 last.

West India and Panama Telegraph Company.—The estimated traffic receipts for the half-month ended February 15 were £3,213, as compared with £3,585 in the corresponding period of 1890.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 20, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,928.

London Platino Brazilian Telegraph Company.—It is intimated by the Company that the coupons on their debentures due March 1 next will be paid on presentation at the banking-house of Messrs. Glyn, Mills, and Co., Lombard-street, E.C.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	1½
Swan United	3½	5
St. James'	—	6
National Telephone	5	4¾
Electric Construction	10	7¼

NOTES.

Berlin.—There are now 100,000 incandescent lamps and 3,000 arc lamps burning in Berlin.

Bohemia.—The town of Chotzen, in Bohemia, is to have a central station for electric lighting.

Manchester Town Hall.—The proposed tenders for lighting this building has been left over until next month.

Civil Engineers.—Prof. J. A. Ewing, B.Sc., F.R.S., has been elected a member of the Institution of Civil Engineers.

Main Lighting in Hungary.—Tudor accumulators are being used for supplying electric light to trial trains on the Hungarian State railways.

Submarine Telephones.—Several ports on the coast of Sweden are intended to be connected by submarine telephone cable by the Government department.

Suakin.—A telegram from Cairo says the Sirdar recommends the erection of a telegraph line between Suakin and Tokar, a distance of 50 miles, showing that he considers the district safe against Dervish attacks.

French Accumulators.—We see it stated in French papers that the difficulties which were raised between the French Accumulator Society and the Tudor Company have been smoothed away—though in which direction is not stated.

Society of Arts.—On Wednesday next, March 11, at 8 p.m., Messrs. Newman Lawrence, M.I.E.E., and Arthur Harries, M.D., will give a lecture on "Electricity in Relation to the Human Body." Mr. W. H. Preece, F.R.S., will preside.

Female Electricians.—M. Marchand, a great advocate of female emancipation, just deceased, has, says *Electricité*, bequeathed a million francs for a college for the technical and professional education of women as doctors, lawyers, and especially electricians.

M. Gaulard.—According to the *Journal des Applications Electriques*, M. Gaulard went mad on account of the disappointment caused by the jury of the Exhibition of 1886 having given the diploma of honour not to himself, the inventor, but to the company who were introducing his transformers.

Durham and Amble.—A letter was read at the monthly meeting of the Durham Town Council from Messrs. Nicholson and Jennings with reference to electric light, but did not produce any comment. The Local Board of Amble received a similar communication, and the clerk was asked to apply for prices.

The Telegraph in Revolutions.—According to the *Petit Journal*, the telegraph was the cause of the failure of the Oporto revolution. Several telegrams to officials, stating that "The sick man will hardly last the night," were noticed, and the Government took alarm, did not deliver the telegrams, but watched instead, with the result known.

Norway.—Hammerfest, the most northerly town in Europe, is the first town in Norway, says *Industries*, to be lighted completely by electricity. The installation is on the Thomson-Houston principle, and the motive power is supplied by a waterfall at about a mile distance. The installation is satisfactory, and will be extended so as to light the harbour.

The Balancing of Engines.—At the Society of Engineers, Town Hall, Westminster, on Monday, Mr. Arthur Rigg delivered a lecture on "The Balancing of High-speed Engines," when the effect of the air-buffer in the Willans engine, and transmission of strains to the foundation, and the method of balancing an independent centre, were discussed.

The National Telephone Company opened an exchange at Leicester on Wednesday, when the through lines were used for the first time, and messages interchanged with Leeds, Bradford, Manchester, Liverpool, and other towns. Hitherto there has been no through communication with the North, the Postal Telephone exchange being purely local.

Anglo-French Telephone.—We have received the following latest official information as regards the London-Paris telephone line. The preliminary work of laying the cable began at Calais on Thursday. The submersion will take place on Friday (to-day) if weather permits. The land wires are not yet complete, but it is hoped they will be ready for service next week.

Madrid.—The Spanish Senate House has recently been lighted from the mains of the Electricity Supply Company for Spain, which has a large central station outside Madrid. The light was on Wednesday night witnessed by Queen Christina, who expressed great satisfaction with it. There are about 1,500 incandescent lamps in the building. The high-tension alternate-current transformer system is used.

Permanent Electrical Museum.—We are glad to see that a committee of the Institution of Electrical Engineers is to be appointed to fully consider the proposed permanent electrical museum in conjunction with the Institution. When, or if it is decided upon, we have a little information about several early and interesting electrical productions that we shall be pleased to put the museum committee on the trail of.

Royal Institution.—Prof. Victor Horsley, F.R.S., will give a discourse on "Hydrophobia" on Friday, March 20, in place of Prof. W. E. Ayrton, F.R.S., who is unable at present to give his promised lecture on Electric Meters, Motors, and Money Matters. To-day, Friday, before the Royal Institution, Albemarle-street, at 9 o'clock, Prof. J. A. Fleming, M.A., D.Sc., M.R.I., will give a lecture on "Electromagnetic Repulsion."

Gulcher Thermopile.—A Reuter's telegram, dated Berlin, March 3, says: "Herr Gulcher has invented a means for increasing the utility or efficiency of electricity by substituting thermal columns for dynamos, using nickel for the positive, and alloxate of antimony for the negative poles. The experiments in the matter have been conducted at the works of Messrs. Pintsch. The invention, however, is still in the theoretical stage."

Grimsby.—The following is the result of tenders for fitting up the Town Hall with the electric light, for the Grimsby Town Council: Crossley Bros., £815 (accepted). The town clerk, referring at the meeting of the Town Council at which the contracts were sealed, said the fitting up of electricity, including gas engine, would be £815, and the electroliers would cost £165 more. The proposed engine-house had been estimated at about £100.

Glasgow Athenæum.—A special type of steam boilers have been fitted up by Messrs. Lindsay, Burnet and Co., in connection with the electric light installation at the Glasgow Athenæum. They are of the firm's special dry-back tubular class for the higher pressures and for comparatively confined spaces, differing essentially from marine boilers in that there are no narrow, flat stayed spaces, which are so difficult to keep free of scale from bad water.

Chinese Telegraphs.—If it be true as reported, remarks the *Indian Engineer*, that the Chinese Government have extended their telegraph line from Yunan-Fu to Momien, direct overland communication between India and

Eastern China can be carried out in a very short time. Momien is distant from Bhamo only 135 miles and there should be no difficulty in linking the British and Chinese telegraph offices, as so short a distance now divides them.

Nottingham.—Writers in the local press are asking the reason why no steps are being taken to introduce electric lighting, and are urging the Corporation to immediately put itself in communication with one of the important companies who are prepared to supply electricity, saying that no doubt the town authorities would be able to arrange the matter on favourable terms. It is suggested that some independent member of the Council would take up the matter.

University Examiners.—Notice is issued by the University of London that on Wednesday, April 29, the Senate will proceed to elect examiners in the following departments (amongst others): Two in experimental philosophy, £210 each; present examiners, Prof. G. F. FitzGerald, M.A., F.R.S., Prof. Oliver J. Lodge, D.Sc., LL.D., F.R.S. Two in chemistry, £240 each; present examiners, Prof. H. E. Armstrong, Ph.D., F.R.S., Prof. W. A. Tilden, D.Sc., F.R.S.

Alnwick.—The Corporation of Alnwick have received an offer from Messrs. Nicholson and Jennings, of Newcastle, to put down an electric lighting station to supply as many arc lamps as are necessary for the streets, to fix lamp-posts, and maintain the light at a yearly rental, to include redemption of the plant in a term of years to be agreed upon, on a similar scheme to that upon which they are lighting Copwen (Blyth). The offer was referred to the Lighting Committee.

Crompton's Concert.—A smoking concert was held at Messrs. Crompton and Co.'s works by the Arc Works Athletic Club last Saturday evening. The concert was varied from the usual smoking concerts, being interspersed with toasts and speeches from members, and the chairman (Mr. Crompton). A distribution of prizes also took place to the winners of the athletic competition, and with the abundance of songs, recitations, cornet and violoncello solos a most enjoyable evening was passed.

Southampton.—The electric light company at Southampton are making active progress with the erection of their works. The streets were up last week with the construction of the culvert for the reception of the wires. The connection has now been made with the work done in the High-street, and the company are now excavating under the tramway line opposite East-street, to carry their wires to the other side of the High-street. The work is being done in a thoroughly substantial manner.

Old Students' Smoking Concert. — The Old Students' Association will hold a smoking concert on Saturday evening next, March 7, at Masons' Hall Tavern, Basinghall-street, City. Members of the O.S.A. will need no incentive to turn up; all old students at Finsbury or the Central who are not members should take the occasion and go, and the sight of so many well-known faces will doubtless induce them to join the association, and help its activity in this and also in more scientific directions.

Manchester.—The Electric Lighting Committee of the Manchester Corporation have been making full enquiries into the different methods of the electric lighting supply of London and elsewhere, and are preparing an exhaustive report upon the subject, to be presented at an early date to the Manchester City Council. In the meantime they are receiving valuable information from the various electric lighting engineers and supply companies in the kingdom, which will be of great service to them in connection with their investigations.

Lighting Railway Lines.—The Pennsylvania Railroad Company have decided to light the seven miles of their track through Frankford and some neighbouring towns by electricity, so as to lessen the chance of accidents caused by the busy traffic and large number of crossings. Arc lamps will be used, and it is hoped to render the track by night as safe as it is by day. Their example might well be followed, thinks the *Globe*, on some of our London lines, especially those connecting termini on the south side of the river.

Aerial Navigation.—M. Gaston Trouvé has an article in *L'Electricien* (No. 8 and 9, new series), on aerial navigation, by means of an apparatus constructed like a bird, which he maintains is the first ever constructed which. being heavier than the air, yet flies. He poses the data of 7¾lb. per horse-power to be the weight of the apparatus, and discusses the use of electric motors, but seems to prefer cartridges formed of compressed hydrogen and oxygen, which should drive a motor by means of explosions, or a set of double reservoirs actuating an extremely strong and forcible but light motor.

Leeds.—At the meeting on Wednesday, Ald. Firth, the chairman of the Highways Committee, in reply to a question, said that he held in his hand an authority from the Board of Trade to proceed with the work of the Roundhay-road tramways. The only variation from the application which the Corporation had made was that the electrical engineer to the Board required that the cars should be worked at 300 volts instead of 500 volts. The committee had communicated with the Thomson-Houston Company to ask if they were prepared to work the line at 300 volts, and he had received a telegram to say that they were.

Experimental Lighting for Bombay.—"We see," says a Bombay paper, "that the Municipal Commissioner of Bombay is advertising in America for tenders for experimental electric lighting. This is a sign of progress that must be very gratifying to patriotic citizens; but we fear that the effect of the move will be rather spoiled by those captious people, living in Sion, Matoonga, and obscure suburbs of the town, who are complaining that they usually have no lights at all in their streets—not even the humble oil-butty." We think also that the effect of the move, if truly described, will not be relished by English electrical contractors.

Monopoly of Lighting at Luxembourg.—It will be remembered that at Luxembourg a dispute arose some time ago between the gas and the electric companies. The Municipality authorised the electric light company to break up roads in order to lay cables. The gas company then brought an action against the town authorities, maintaining it had a monopoly of public and private illumination, and that the concession to the electric company was a breach of the agreement. The suit was determined against the gas company on the ground that monopoly only referred to gas lighting. The gas company appealed, and the decision has just been confirmed. The electrical company will now be allowed to proceed.

Birkenhead.—A sub-committee of the Watch Committee of the borough of Birkenhead have had under consideration the better lighting of the borough, and have come to the conclusion that the borough is badly and insufficiently lighted. They recommend that the central and principal streets should be better lighted by alterations being made in the existing lamps, and the erection of 120 new lamps in various parts of the borough. The estimated annual cost of the additional lighting of new lamps is put down at £776. 10s., and the probable alterations are estimated at £755. These recommendations, the sub-committee state, are only an instalment of the improvements they think should be carried out.

Electricity in Mining.—The employment of electricity for mining purposes is rapidly becoming a most important industry in this country. England being the largest coal-producing country, efficient means for colliery purposes are likely to be adopted here in ever increasing quantity. We notice many new firms taking up this branch of electrical engineering, and lately an important indication is given in special electrical supplements issued by the *Iron and Coal Trades' Review*. These contain a series of articles specially contributed on "The Dangers of Electricity in Mines," Bolton's article on "Electric Cranes," Pope on "Electric Railways," and various notes of the use of electricity in collieries.

Street Railway Review.—While we are pottering along with one or two street electric railways (we reserve credit for the subways) the Americans are still forging ahead with unexampled rapidity. One of the best indications of this is the appearance of another new journal hailing from Chicago (334, Dearborn-street) entitled the *Street Railway Review*, the first number of which is before us—a large thick journal of 100 pages, beautifully printed and got up generally as is their wont, and containing articles on noiseless motors, Wenstrom's electric works, large electric cars, electricity in snowstorms, electric railways of North America, besides a description, entitled "In Deepest London," of our own success in electric traction—the Southwark Subway.

Matlock Bath.—A report has been received from the engineer appointed to make investigations with regard to the lighting of Matlock Bath Local Board district with electricity. At the monthly meeting of the authority on Tuesday night it was stated 225 promises for accepting lights for private consumption had been received at £1 each per year. The cost was estimated at £1,300 to £2,500, according to the requirements. Mr. F. C. Arkwright, who has the right of the water, had not been seen, but it was not anticipated there would be any difficulty in that direction. The Board will have a special meeting on the business to decide whether to take up the proposal on behalf of the ratepayers or get a company to float the concern.

Preston.—The central station of the National Electric Supply Company at Preston, which has been in course of erection for some weeks past, has now got to work. Two engines, respectively of 120 h.p. and 40 h.p., drives four Blakey, Emmott, and Co.'s dynamos, capable of supplying each 1,800 16-c.p. lamps. Large square posts are set up in the streets (temporarily, only, it is understood), each with a globe containing three lamps each, for public lighting free of charge. There are already 500 lamps running on two distinct circuits, and are supplied from dusk to midnight at £1 per lamp per year, including connections and fittings. The Theatre Royal and Lipton's store have arc lamps. Dr. Aron's meter is intended to be introduced shortly.

Telephone Rates.—A correspondent writing to the *Glasgow Herald* with reference to the proposed Mutual Telephone Company wants to know if the numbers of the new company will be the same as the old, having had two years' stock of stationery printed with their number on it. Since he paid his year's rent, of which there are seven months yet to go, the National Telephone Company have intimated a reduction in the rate, but he wonders whether the difference has been refunded to those subcribers who have paid the old rates for the current year, or whether it is their intention to do so. It will lead to great confusion to have two separate companies, and seeing the National Company took advantage of the monopoly and kept up the rates as they did, it is maintained that the Mutual Company ought to get the entire support of the public.

Electric Alarm.—Mr. John Bellamy, engineer, of Bing-street, Millwall, has reason to see the utility of electric burglar alarms. Owing to his premises having been broken into no fewer than five times during the last 14 months they were fitted with electric alarms, which communicated with the bedroom of Thomas Turner, an employé who resided in the next house. About one o'clock in the morning of Saturday week Turner was awakened by hearing the electric alarm ring. He got up and speedily went for assistance. On the arrival of the police the office door was opened, and two men were found concealed beneath a desk. A third man was also seen, but he succeeded in making good his escape. Both prisoners were committed for trial.

Rome.—The work of installation of the electric tramway to connect the Place del Popolo and the Ponte Mollo, at Rome, are complete, and the line of about the length of 1½ miles has been started. The *concessionaire* is M. Cattori, who placed the work in the hands of Messrs. Foote and Von Buch. Two 60-h.p. engines drive two Statter series dynamos, giving 52 amperes at 850 volts, one set being for reserve. The overhead line of four silicious bronze wires is carried 22ft. above the ground. There are three cars, each carrying a 15-h.p. series motor, and regulation is obtained by a shunt resistance. The line is run in sections in series, automatically worked by the passing cars. The introduction of the resistance of ·1 ohm in the motor circuit is sufficient to reduce the power of the motor to 4 h.p.

Destruction of the Japanese Parliament.—Details are forwarded to the cable agencies of the fire at Tokio which resulted in the complete demolition of the newly-completed Houses of Parliament. They were built of wood, and cost 800,000 yen. The origin of the fire was at first attributed to the soshi, a political class who seek by violence to carry out their views. A closer examination, however, is said to have revealed the fact that the fire originated in the electric wires, although the actual cause of the defect has not been ascertained. The disaster so startled the Emperor that he immediately gave orders to have all the electric lamps removed from his palace, but subsequently countermanded these orders and engaged a private staff of electricians, giving them instructions to lay down an electric motor for the sole use of the palace.

Electricity at Ambleside.—At the special meeting of the Ambleside Local Board to consider the taking over of the gas and water company, a letter from Colonel G. Rhodes was read, strongly urging the Council to let it alone, for the interest both of the shareholders and the Council. "The electric light," he goes on to say, "will eventually be established for Ambleside and district, and electric launches are to be placed on Lake Windermere. Electric 'busses will follow, and then a 20 to 30 minutes' drive from Windermere to Ambleside at a 6d. fare will be the result. The electric cars will supplant our four-horse coaches, same as the steam-engine railways have already done. Establish electric lighting, and the gas company will equally benefit, and more gas will be consumed." A committee was eventually formed to consider the purchase.

Anglo-German Cables.—The intolerable disturbances of the system of telegraphic communications between England and Germany, which occur even in comparatively fair weather, are now, says the *Standard*, to be radically dealt with. There are only two cables between Emden and Lowestoft, and it is to this cause that most of the trouble is due. The Governments of the two countries have at length considered the constant complaints on the subject, and have agreed to lay a third cable. Each Government is to bear half the cost, which will amount in all to about £120,000. A Bill on the subject will soon be laid before the Reichstag, and the operations for laying the cable will commence immediately upon the money being granted. A new cable will also be laid to Heligoland from the Island of Wangeroge, which is already connected by cable with Wilhelmshaven.

Hamstead Colliery.—The Hamstead Colliery Company, of Great Barr, near Birmingham, has been lighted by electric light. The plant, which is contained in a separate building on the surface, comprises a Willans engine and a Hookham dynamo, having an output of 10 amperes at 500 volts pressure. The installation is equal to 50 lamps of 16 c.p. Steam is supplied to the engine from a set of boilers used for furnishing steam to all the surface engines. By means of overhead conductors, the current passes to two circuits, one being taken down the shaft. The main roads, office, stables, and bottom decks are lighted, but no lamps are installed in the workings. At night time the two circuits are run for lighting the engine-rooms above ground and pitheads as well as below. The installation, which has been carried out by Messrs. Chamberlain and Hookham, has been in successful operation for some time.

Meteorological Exhibition.—The Royal Meteorological Society's twelfth annual exhibition of instruments was opened last Tuesday evening in the rooms of the Institution of Civil Engineers. The exhibition this year is devoted to rain and evaporation gauges, and such new instruments as have been constructed since the last exhibition. Almost every known pattern of rain gauge that has been used in this country is shown, and some interesting storm gauges and self-recording gauges are also exhibited. The evaporation gauges include several instruments employed for measuring the evaporation from a free surface of water, and others for use with growing plants. A number of new instruments are also exhibited, among which are various anemometers, recording barometers, and cameras for meteorological photography. The exhibition will remain open till Thursday, 19th inst.

Electrical Drills.—The audience at the Society of Arts on Monday were much interested in seeing Mr. Kapp manipulate the electric drills and cutters and borers. The electrical drill embodies the important application, invented by Mr. Rowan in 1882, of the use of strong electromagnets to hold the drill in its place—on the ship or boiler side, or wherever it may be required. This sucker action is turned on before the drill itself acts. The efficiency of the drills in actual work was stated to be 66 per cent. We notice that in a contemporary Mr. W. H. Willatt, replying to Mr. Rowan in relation to the invention of these drills, while acknowledging the master patent for the use of magnets for holding, repudiates any suggestion that Mr. Rowan must design every form of electrical drill until the expiration of that patent, and mentions that in the spring of last year he designed a special electrical drilling machine for the Earle's Steamship and Engineering Company to bore 2⅜in. hole in a sloping deck.

Consulting Engineering.—The *Freeman's Journal*, in a leading article, alludes to our recent action upon the needed reform in consulting engineering practice, and after quotation from our article, draws the attention of the Dublin authorities to the matter in the following words: "The sum and substance of these general remarks may be briefly stated. Consulting engineers, it is contended, should draw up plans and specifications to guide contractors, and not merely issue a few guiding clauses, leaving the contractors to make their own specifications. Naturally the *Electrical Engineer* writes from the electrician's point of view, but it is certainly open to argument whether the system of adopting fixed specifications and plans would be workable in practice, and it obviously would not be so favourable to public bodies. At the same time we are far from denying that an able engineer who sends in a tender, and finds his ideas appropriated without any reward, has a legitimate ground of complaint."

Electric Lights for Lightships.—The American Lighthouse Board is considering the feasibility and advisability of placing electric light beacons upon several of the new lightships to be stationed along the Atlantic coast, which are now in course of construction or under contract. It is stated that it was originally intended to equip these vessels with the best modern lights which could be obtained and the lenses and lamps to be of the highest order. It is thought possible, however, to obtain a better light by the use of electricity, in which case it would be desirable to equip the new lightship which is to be placed at Sandy Hook, and one or two others, with the electric light. In order to ascertain if the benefits which an electric beacon may possess over the regulation lamps will justify the additional expense, the Lighthouse Board will undertake a series of experiments to be conducted at the lighthouse station on Staten Island. It is also proposed to equip two or three of the new lightships with flash lights, to be produced by means of revolving shades. The system of electric lights now in use on the buoys in Gedney's Channel, in New York Bay, are reported to give perfect satisfaction.

Telephone Subways.—The London County Council have had before them an application from the Universal Telephone Company for permission to run two wires, twisted together, in the subway of Northumberland-avenue, for the purpose of establishing communication between the Hotel Metropole and the Grand Hotel. There appears to be no objection to this proposal; but the Highways Committee are of opinion that the company should be called upon to pay a small rent for the use of the subway for the purposes of its business. They therefore recommend that the Universal Telephone Company be allowed, during the pleasure of the Council, to run their two wires upon condition that the positions in which the wires shall be placed in the subway shall be determined by the Council's chief engineer; that the space occupied by them shall not exceed that which would be taken up by a 2in. pipe; that the work of placing them shall be carried out, and that any damage that may be done to the subway in the execution of the work shall be made good, to the satisfaction of the Council's chief engineer, and at the cost of the company; and that the company do agree to pay a rent of £1 a year in respect of the use of the subway during the time that the wires remain there.

Telegraphs to Lighthouses.—The subject of telegraphic communication with lighthouses, lightships, and lifeboat stations was discussed at the meeting of the Associated Chambers of Commerce on Wednesday, on the resolution of the Cardiff Chamber, seconded by the Plymouth delegate, who proposed that these places should be placed in telegraphic communication with the general telegraphic system. The motion was supported by Sir C. Palmer, M.P., Sir H. Waring, and others; and Sir Michael Hicks-Beach, M.P., in speaking upon it, said he hoped the Chambers, if they came before him upon this subject, which, so far as it affected the saving of life, could not be overrated in its importance, would be prepared to say from what fund the costs should be paid of making the suggested communications, for if the costs should fall upon the Commercial Marine Fund, there would be an increase of the light dues, and he had not gathered from the discussion that the Chambers were in favour of this increase. The president, speaking on behalf of the shipping interest, said that if the telegraph communications between lighthouses and the land would save life the increase of the light dues would be cheerfully borne, and he hoped the matter would be taken in hand at once. The resolution was carried.

Low-Tension System for Islington.—The Works Committee of the Islington Vestry reported on February 20 that they had considered the draft provisional order of the Camberwell and Islington Electric Light and Power Supply Company, by which authority is sought to supply electricity in the parish for the purposes of both light and power on the low-tension system. The system proposed to be adopted by the company is entirely different to that of the House-to-House Company, to whose order the Vestry consented last year, the former being on the low-tension system, which enables the company to supply electricity not only for lighting, but also for power and other purposes; while the latter is on the high-tension system, with transformers on the consumer's premises. The committee was of opinion that, subject to certain requirements being complied with, and to a satisfactory understanding being arrived at as regards minor details, the Vestry should give its consent to the order. Mr. Furlong, in moving the adoption of the report of the committee, said that this company had promised to move in the matter as soon as they obtained a provisional order, and it was a fact that they had secured premises near the Vestry Hall, so that now there seemed to be a good chance of the main thoroughfares being lighted by electricity. Mr. Vine, in seconding the adoption of the report, remarked that the company not only proposed to supply electric light, but electric power for various trade purposes. In reply to Mr. Cussans, the vestry clerk said that the wires were to be placed underground. The proposition was carried unanimously.

Chelsea.—The Electric Lighting Committee of the Chelsea Vestry reported that they had considered the letter from Mr. R. Chamberlain, M.P., dated February 3rd, thanking the Vestry for their letter of January 31st, transmitting copy of a letter addressed by the Board of Trade to the Chelsea Electricity Supply Company in reply to their application for permission to discontinue the supply of electricity during certain hours of the day; asking the Vestry to take into consideration the question of appointing an inspector under the Electric Lighting Acts, and suggesting that the duties might be performed by one of the existing officers. The committee have ascertained that the number of houses supplied, or about to be supplied, by electricity in the parish is as follows: Chelsea Electricity Supply Company, Limited, 215; Cadogan Electric Light Company, Limited, 16; London Electric Supply Corporation, Limited, 2; but are unable to make a recommendation in the sense indicated by Mr. Chamberlain. The committee also reported that they had considered the letter from the Cadogan Electric Light Company, Limited, dated February 4, stating that they are at the present time working under an agreement with the Vestry; and being about to transfer their business to a newly-formed company—viz., the New Cadogan and Belgrave Electric Supply Company, Limited—they beg respectfully to ask if the Vestry will consent to the transfer of the said agreement to the new company, who will be bound by the conditions therein stipulated. On this the committee recommended "that the Cadogan Electric Light Company, Limited, be informed that the Vestry prefer that the company should obtain a provisional order authorising them to supply electricity in the usual manner." These reports were approved, and the recommendation adopted.

Lecture at Glasgow.—Before the Institution of Engineers and Shipbuilders at Glasgow, last week, Mr. Henry A. Mavor read a paper on "The Development of Electrical Distribution." The problem of the economic distribution of electricity, he said, was daily becoming of greater importance as it application to various industrial and domestic purposes extended. The enormous rapidity with which its extension was taking place created the problem, and the solution of it was an immediate necessity. The most prominent application was, of course, to electric lighting; but it was a curious fact that theoretically this was one of the least promising of its applications. The public recognition of the value of electricity as a light-producer probably arose from its possibilities in this direction having been first developed. Mr. Mavor then proceeded to describe the methods of distributing electric energy, showing how complicated arrangements for the public service had grown out of the simplest original systems. He described the manner in which conductors were laid underground and overhead, and the arrangements for the utilisation of the currents from these conductors for the purpose of the electric traction of street railways. In closing, he pointed out the immense value of such a method of transmitting power, exhibiting a 2in. iron pipe, which contained conductors on the Brooks system, for the transmission of 1,500 h.p. over 12 miles, with a loss of only 2 per cent. Lantern illustrations were shown of the plan adopted in America for overcoming the difficulty of placing conductors underground, and an explanation was given of some of the applications of stored electricity to locomotion. The discussion on the paper was adjourned till next meeting.

Central London Railway.—The Bill for the Central London Railway came before a committee of the House of Commons on Tuesday. Mr. Pember, Q.C., in opening the case for the promoters, said that the proposed line of this year was six miles long, as against 4½ miles last year, and that it was intended to run 50ft. underground from Shepherd's Bush to Cornhill. The shield process of excavation would be used. The total capital of the company was £2,700,000 in shares and £900,000 borrowing powers, the railway to be completed in five years. The motive power was to be electricity. The vibration of the railway would be not heard on the surface, and the trains would make their own ventilation. The maximum speed was to be 25 miles an hour, or 15 miles an hour including stoppages, 25 per cent. quicker than the Inner Circle trains. A passenger would be able to get from the Marble Arch to the Bank in a quarter of an hour. The company did not seek power to break up the streets, and clauses would be inserted for the protection of the sewers and gas and water-pipes. He also pointed out the necessity for some further means by which the present congested state of the traffic in the streets of the metropolis could be alleviated. As an instance where a line of this kind had been worked with success by electricity, he might mention the Manhattan Railway, which in 1889 carried 179,000,000 passengers over a mileage of 32 miles, the gross earnings being £56,000 a mile. He alluded to the success of the City line. On the proposed line the tunnels would be larger, the stations more commodious, and the service quicker, and running on every day of the week. Mr. Greathead, engineer to the line, then gave evidence. On Wednesday, Sir Benj. Baker, Dr. Hopkinson, on technical, and Mr. Hamilton Smith on financial matters, were examined. The opposition evidence will next be taken.

THE POST OFFICE INSTALLATION.

(*Concluded from page* 186.)

It may be well to give some mention of the feed-water heater used in this installation. This is Atkinson's patent, made by the British Gas Engine Company, Gospel Oak. The use of the heat from the exhaust steam to warm up the water before going into the boiler, is combined with entire freedom from back pressure, accommodation for unequal expansion, purification of the water, and facility for cleaning out or examination. The feed-water heater is shown in elevation and section in the accompanying illustrations, Fig. 12. The exhaust steam from the engine enters at the pipe marked "steam inlet," and passes away in a direct unimpeded course through a channel of similar sectional area throughout to the "steam outlet," from which the exhaust pipe conducts the steam not utilised in heating the water away in the usual manner. This channel is, however, open at the top to the tube plate, into which are screwed the ends of a number of vertical tubes, open to the exhaust steam below but closed at their upper ends, which are thus left to expand or contract without straining. In each of these heating tubes is a small circulating tube leading from near their upper ends to the channel, through which the exhaust steam passes at a speed of nearly a mile a minute. The mouths of these tubes are bent, as shown, in the direction of the exhaust steam, so that the steam in passing causes a strong induced current out of them, rapidly removing the air they first contain when commencing to work, and causing the very slight amount of expansion required to create an up current and fill them with steam. The heating tubes are thus filled with exhaust steam at a constant temperature of 212deg. F., and as the space around them is filled with water, they rapidly transmit the heat of the steam to this water, automatically drawing up as much steam as they require. The remaining steam not only passes unchecked, but by being reduced in volume from one-third to one-half, it passes through the remaining length of the exhaust pipe with less resistance than at first, and the engine thus actually works with less back pressure than if the feed-water heater were not attached.

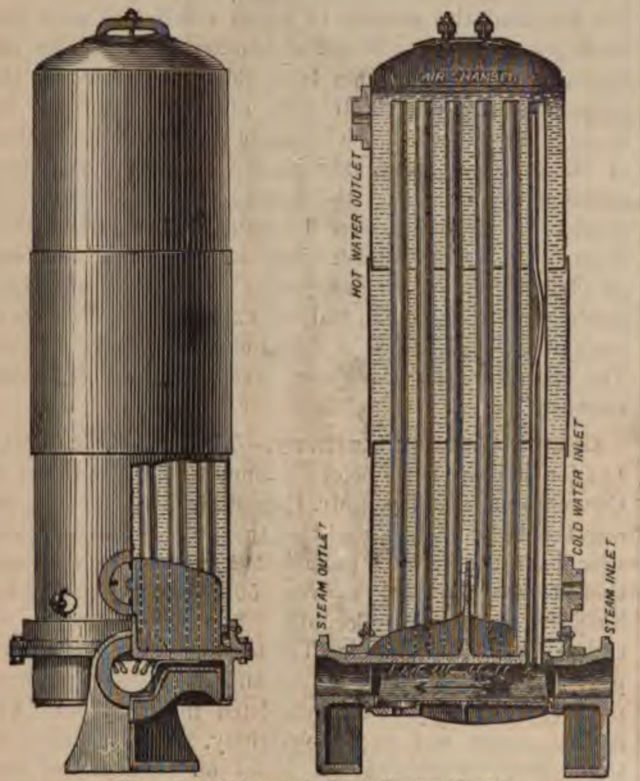


FIG. 12.—Atkinson's Feed Water Heater.

The cold water is pumped into the lower part of the water-cylinder at the point marked "cold water inlet," when it is rapidly heated to a boiling temperature, passing to the top, and the same action forces the boiling water into the boilers. The water-cylinder is large enough for the same to spend some time in passing through and thus deposit any impurities; the lower part of the cylinder is divided by a partition, which prevents the disturbing influence of the entering cold water from affecting the hot water on the other side, thus allowing the impurities to settle there as soft mud. A blow-out cock is provided for occasionally removing this mud.

With the use of this apparatus one-fifth of the total work in making steam is done by the heater, and the remaining four-fifths is carried on with greater relative economy, as the loss of water from priming passing, leaky cocks, etc., is obviated by the use of boiling feed-water. The total saving from these causes will vary, but it is guaranteed by the makers to exceed 20 per cent., and is stated to be frequently as much as 25 per cent. Four boilers and one heater will therefore do as much work as five boilers of the same size without the heater, which costs far less than a boiler, besides the saving in fuel and to the boilers by the prevention of local strains from cold water. By preventing the actual contact of the exhaust steam with the water heated, no grease can get into the boiler. The absence of back pressure is a more important point than might at first appear. With water-heaters that receive the steam into a chamber the momentum is lost, and it must again start and be forced through the tubes by the energy of the steam from the engine, and back pressure on the engine must result. Taking a back pressure of only 1lb.—a moderate estimate, as it is not unfrequently 3lb. and upwards—with a boiler pressure of 45lb., the mean pressure on the piston would be about 25lb., out of which 1lb., or 4 per cent. of the available power of the engine, is lost in forcing the exhaust steam through the heater. But with the ingenious arrangement adopted, the back pressure is even less than with an open pipe.

Having indicated the boiler arrangements, we will return to the dynamos and their circuits.

Under the floor of the dynamo-room a sloping brickwork culvert has been built to receive the cables leading from the dynamos to the main switchboard. When building, the culvert has had iron hooks fixed therein at proper intervals to carry the cables. In laying the cables, each cable has had strung upon it a number of brown earthenware insulators. These are slipped along to their right distance along the cables, and are then placed upon the iron hooks, thus serving as simple means of insulating and carrying the conductors in the culvert. The culvert is sloped both to allow for the varying numbers of the cables, and also to allow any moisture that may happen to get into it to drain away.

The installation is wired in two distinct circuits throughout. In usual working, dynamos 1, 3, 5 are to be run in parallel on circuit 1, and dynamos 2, 4, 6 on circuit 2. The cables from the dynamos are taken first to the main switchboard in the engine-room, and from thence to the various floors, each floor having its own distributing switchboard, and thence to the lamps, each lamp having its own switch.

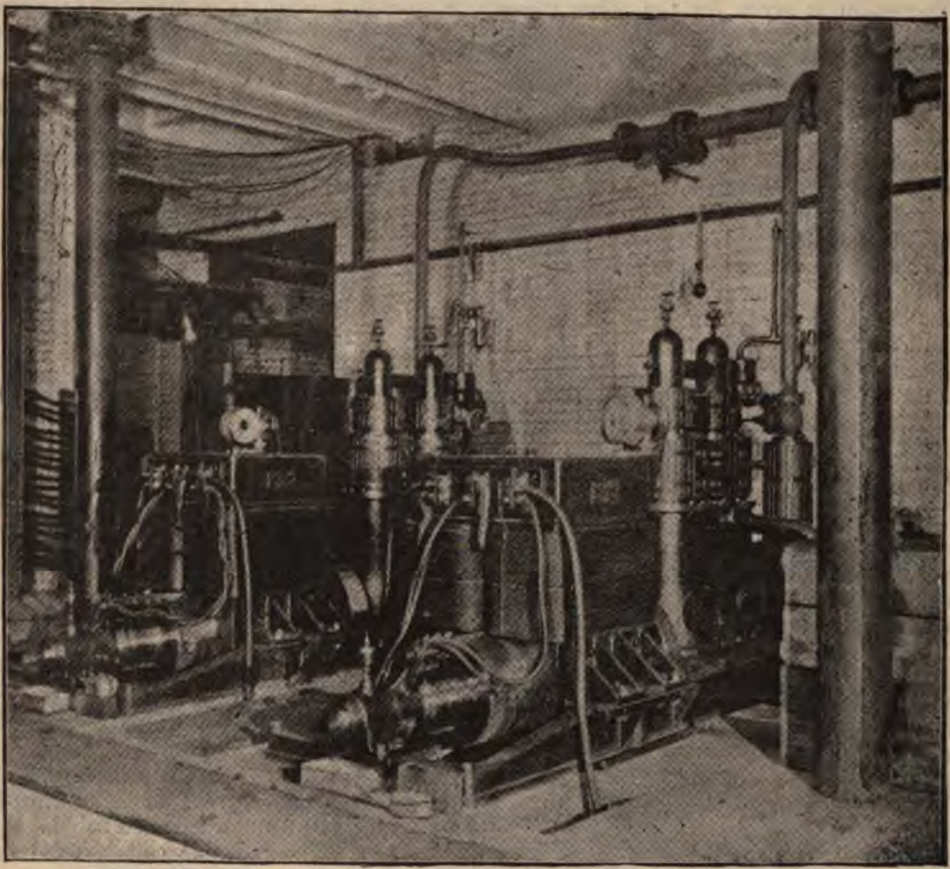
The dynamo switchboard is constructed with two rows of switches, the first row for the positives, the second row for the negatives. The switches are of a peculiar and special construction, already shown in Fig. 1 previously given. There are six of these switches in each row, one for each dynamo, and each switch is constructed to feed on to eight distinct circuits as desired. As will be seen on turning back to refer to the illustration, the switch has eight handles standing out; by moving the handle, the detail of which is shown above (Fig. 1, p. 136, Feb. 6), connection is made across from the circuit desired to the central block, which is connected, as the case may be, to the positive or the negative pole of one of the dynamos.

The total of 12 eight-way switches are mounted upon one large switchboard at the end of the dynamo-room. The connections are, as shown in Fig. 5 (p. 158, Feb. 13), made by solid copper strips at the back of the board. The round dots represent the terminals of the switch, the cable from the dynamo being led in each case to the centre contact, and connection is then made across as required by moving the switch handle. It is thus easily seen that any dynamo may be switched on to any circuit by moving the handles belonging to this circuit upon the positive and negative switch under the number of the dynamo required.

The dynamos are numbered 1 to 6, and each is furnished with a Dolivo ampere-meter for 600 amperes placed above the switches. This switchboard was manufactured to drawing by the General Electric Company, Queen Victoria-street.

On the wall opposite the engine, and in full view of the driver, are placed two large voltmeters, one in each circuit, giving the electric pressure at the dynamo. Upon the other wall are two more voltmeters, to which wires are led from a distant point in the building, thus indicating the working pressure upon the lamps in actual use. The driver has thus under his eye all the information required for perfect regulation of his machinery. Every cable and wire in the building has been calculated for a fall of 2 per cent. in the E.M.F. The unsoldered connections, such as fuse-boxes, will take 1·2 per cent. This allows a little over 1½ per cent. in the engine regulation to afford a working pressure of 105 volts in the lamps.

From the switchboard the cables are led to distributing switchboards situated one upon each floor—basement, ground, first floor, and second floor. The details of the switches for these are shown in Fig. 2, already given (Feb. 6), and the general arrangement of the whole distributing board is shown in Fig. 3 same date, p. 138. The ground floor is divided up into five distinct circuits, named A, B, C, D, and E. The mains from the two principal circuits, named 1 and 2, are led to the main terminals at the bottom of the board—those from No. 1 to terminals 1 – and 1 +; and those from No. 2 to 2 – and 2 +. From here the circuits go through the respective ammeters 1 and 2; and thence are distributed to the distributing switches, A, B, C, D, E. These switches are of special construction to allow any circuit to be connected to No. 1 and No. 2 circuit as desired. It will be seen that each circular switch, Fig. 3, has two inner ring contacts marked + + and – – respectively. The + ring is connected behind the board to the + terminal of a fuse-chamber board (described presently), to which one end of the actual lamp circuit is joined, and the – ring goes to the circuit switch "ON, OFF," and so to the – terminal of the fuse-board, to which the other end of the actual lamp circuit is joined.



One Bay of Dynamo Room, Post Office Installation.

The detail of the circular switch is shown in Fig. 8 (p. 160), where the contact-piece not indicated in the larger figure is seen. This contact-piece connects the upper inner contact to one of the outer contacts, and the other inner contact to the diagonally opposite outer contact—the two switch bar pieces being insulated from each other. Now, by turning the handle of the circular switch, A, to one side, so that the bar connects the ring + to the contact 2, and the ring – to the contact 2, Fig. 3, the corresponding lamp circuit, A, will be thrown on to the dynamo circuit No. 2. By turning the lower triangular switch A to the position "ON" the lamps are then turned on. On the contrary, if the handle of the circular switch is turned in the other direction the contacts are made with circuit No. 1, and this can, of course, be done with any of the branch circuits, A, B, C, D, or E, as required. In this way, by a glance at the ammeters, the amount of current in main circuits 1 and 2 can be seen, and can be regulated by turning the handles to make contact with terminals 1 and 2 of the interchangeable switches, as the case may be.

Below the distributing switchboard is placed the fuse-chamber board, of which a general view (it should be looked at sideways) is given in Fig. 7 (p. 160). The fuses guarding lamp circuits, A, B, C, D, E, on circuit 1 are so marked, all the negatives being to one side, and all the positives to the other. The lamp circuits for circuit No. 2 are lettered *a*, *b*, *c*, *d*, *e*.

The details are shown in Fig. 6 (p. 159). Each fuse-chamber is lined with slate slabs, and has a glass front. The fuse is inserted and fastened by means of the screws. The floor of the fuse-chamber is sloped downwards to allow any melted metal to fall to the back and thus to prevent the glass front from being cracked.

The lamp circuits taken from these points are led in wood casing on the surface of the wall or ceiling along the rooms to be lighted. Each branch from the lamp circuit has its fuse, placed fully in sight and just beyond reach of interference, but easily within reach of an attendant with a short ladder.

Having followed the conductors from the dynamo to the lamps, we now come to the system of distribution in the rooms themselves. The chief consideration in the first place has been the full and sufficient lighting of the great sorting-rooms on the ground floor. These long halls present a very busy appearance when viewed from the little gallery above at about half-past five in the evening, when the mails begin to come in. Long rows of sorting-tables run down the length of the hall, each having in front of it pigeon-holes marked with the names of the centres of London and the principal railway routes, into which the clerks rapidly sort the various bundles. The lighting is obtained by arc lamps, disposed as below.

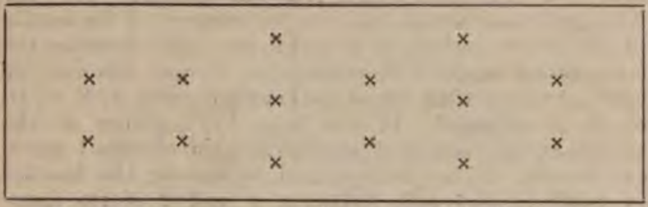


FIG. 13.—Arrangement of Arc Lamps in Sorting-room.

There are thus 14 arc lamps in the first sorting-room, and a similiar disposition is given for the other rooms, making in all 60 arc lamps. Great pains have been taken to obtain the best general illumination to throw a full light on all the tables and racks and avoid all cross shadows, the place of the tables having been all previously set out and the angles of diffusion graphically represented to obtain the best arrangement. The lamps are hung 14ft. from the ground, so that the light is given to the points most required from an angle of 45deg. The lamps are not arranged with sliding pulleys and loose coils of cable, but are fixed at the height named, which can easily be reached by the attendant by means of a light tressel. The lamps are run two in series off the 110-volt circuit and burn most admirably and steadily; the man who is in attendance has watched for the flickering, and has been unable to detect variation for hours together. The sets of two lamps are arranged alternately upon the two different main circuits, so that the accidental failure of one would yet give good general illumination. This principle has been carried throughout, and alternate lamps or groups only are upon the same circuit, the intermediate ones being on the second circuit.

In the circuit of the arc lamps an ingenious electro-magnetic arrangement has been adopted by Mr. Brockie, which sets up a counter E.M.F. directly the arcs are struck, and enables the lamps to burn steadily within a few seconds of switching on, without the irritating "pumping" effect often experienced with arc lamps run in series in the manner here adopted.

The gain in comfort and purity of air has been most marked and noticeable. Late in the night in crowded times, when gas was employed, the atmosphere used to become almost insufferable, and to use a picturesque expression given by the men, "could be cut by a knife." Now the air remains far cooler and comparatively pure, and with the increased energies of their staff of 3,000 men, it is almost as good as an extra 500 men.

The side rooms and upstair rooms on the first and second floor are lighted with 16-c.p. incandescent lamps, each electric light replacing a gas jet. The lamps are placed upon standards, which carry large green shades to reflect the light downwards and protect the eyes, and these are made fixed to prevent interference. The wiring, however, is not carried up the tables, but a cord is dropped down from casing in the ceiling to the fixed standard. This arrangement saves expense in casing, and makes everything visible. Each lamp has its own switch, and the men are required to turn off their lamps when not in use. Besides the more delicate lamp fuses, which are placed in conspicuous positions, but well out of reach of passers-by, there are also at every service branch from the lamp main double-pole main fuses, set to go at 100 per cent. over normal current.

In the registered letter department the experiment has been tried of lighting by 50-c.p. incandescent lamps, arranged in between the tables at longer distances, but the experience of the clerks does not seem to favour this arrangement, and the rooms fitted with 16-c.p. lamps are found to give the best light for sorting purposes.

The whole of the arrangement and installation of this plant has been carried out, under the direction of the chief engineer to the Post Office, Mr. W. H. Preece, F.R.S., by his able assistant, Mr. I. Probert, electric light engineer to the Post Office, who has personally superintended the whole work in connection with the necessary calculations, preparation of the drawings, and the details of the switch-boards and fuses, which have been worked out to special designs to embody the necessary safety and facility of manipulation for such a large and important institution.

The whole of the engineering work has been supplied and carried out by Messrs. Willans and Robinson, the names of the actual makers of boilers and special machinery having been already given. The wires and cables have been supplied by the India Rubber and Telegraph Company, Silvertown; Henley's Telegraph Works Company; and Messrs. Walter T. Glover and Co. The switchboards were made to design by the General Electric Company and the Acme Works. The incandescent lamps, of course, are by the Edison-Swan Company, and the Brockie-Pell arc lamps by Messrs. Johnson and Phillips. The wrought-iron brackets for the outside arc lamps were designed and manufactured by Messrs. Lea, Sons and Co., of Shrewsbury. The whole plant makes a model installation of arc and incandescent electric light, reflecting the highest credit both upon the officials of the Post Office and the numerous firms who have co-operated to carry out the details, and will long remain a standard for the realisation of the best modern conditions of an important electric lighting scheme for concentrated public buildings.

THE FRAGER ELECTRICITY METER.

This meter, which was described some time ago in *La Lumière Electrique*, has since undergone some important alterations, most of which will be seen in the accompanying illustrations.

It has been very favourably received, and the owners have obtained excellent reports of its accuracy from some of our eminent authorities, but being of French origin, it has naturally been employed more universally in France than elsewhere, although a considerable number are in use here.

Although it appears at first sight somewhat complicated, it is really extremely simple and accurate, which is, after all, its chief recommendation. It consists of three parts—viz., a wattmeter, an electrical clock (actuated entirely by the current), and the registering mechanism.

Wattmeter.—The wattmeter is composed of a fixed series circuit made up of two parallel coils, A A′, Figs. 1 and 2, through which the whole current to be measured passes in series with the lamps and a movable bobbin, B, in parallel with the lamps. The movable coil is fixed on a hollow shaft, through which passes the fine wire suspension, F F′, which, being fixed rigidly at both ends, serves, at the same time, the purpose of a torsion spring. When the current passes, this movable coil takes up a position of equilibrium between the force of mutual attraction between itself and the series coil, and the resistance of the torsion spring; this position indicates the energy in the circuit at the time, and the needle, L N, acts as the medium between the wattmeter and the dials, as we shall see.

Electrical Clock.—The electrical clock, which beats seconds, consists of a horizontal pendulum, $j\,l\,h$, Figs. 3 and 4, having a rotary motion, fixed on a vertical axis, m. The movement of the pendulum is started and maintained periodically by a fine wire coil connected to the two terminals, 1 and 2. The spring switch, c, is in the circuit of the bobbin, a. When the pendulum is at rest the tooth, ρ, of the switch takes up its position in the notch in loose washer, e, on the top of axle, and the spring of the switch makes contact at d. When the current is turned on, the soft-iron end, j, of the pendulum is drawn into the centre of the bobbin, and the pin, t, in the top of the axle moves the loose washer, e, and by doing so throws the tooth, ρ, out of the notch, and thereby breaks the circuit; when the current is thus cut off, the pendulum, under the influence of the spiral spring, s, flies back, and just when its other soft-iron extremity, h, arrives at the mouth of the solenoid, the loose washer, *e*, allows the tooth, ρ, to enter the notch again, and contact is re-established, and the pendulm, being attracted in the opposite direction, acquires a further impetus with each simple oscillation. These repeated impulses would develop, if continued, oscillations much too large, but they are checked by the regulating washer, *f*. This washer, *f*, is mounted underneath *e*, but is also loose on the axle of the pendulum, and partakes of its movement by means of a tooth attached at right angles to the plane of *e*, free to move in a keyway in the side of *f*. This washer, *f*, also has a notch for the tooth, ρ, of the switch, but its movement in relation to the washer, *e*, is such that when the oscillations of the pendulum become too great the two notches do not correspond, and consequently the contact remains broken till the amplitude of the oscillation is reduced. When the current is turned off altogether this oscillating movement ceases gradually, and the washers, moving through a smaller arc each successive oscillation, are brought into a position nearly symmetrical with the position of rest of the pendulum, the tooth falls into the middle of both notches, contact is established, and the instru-

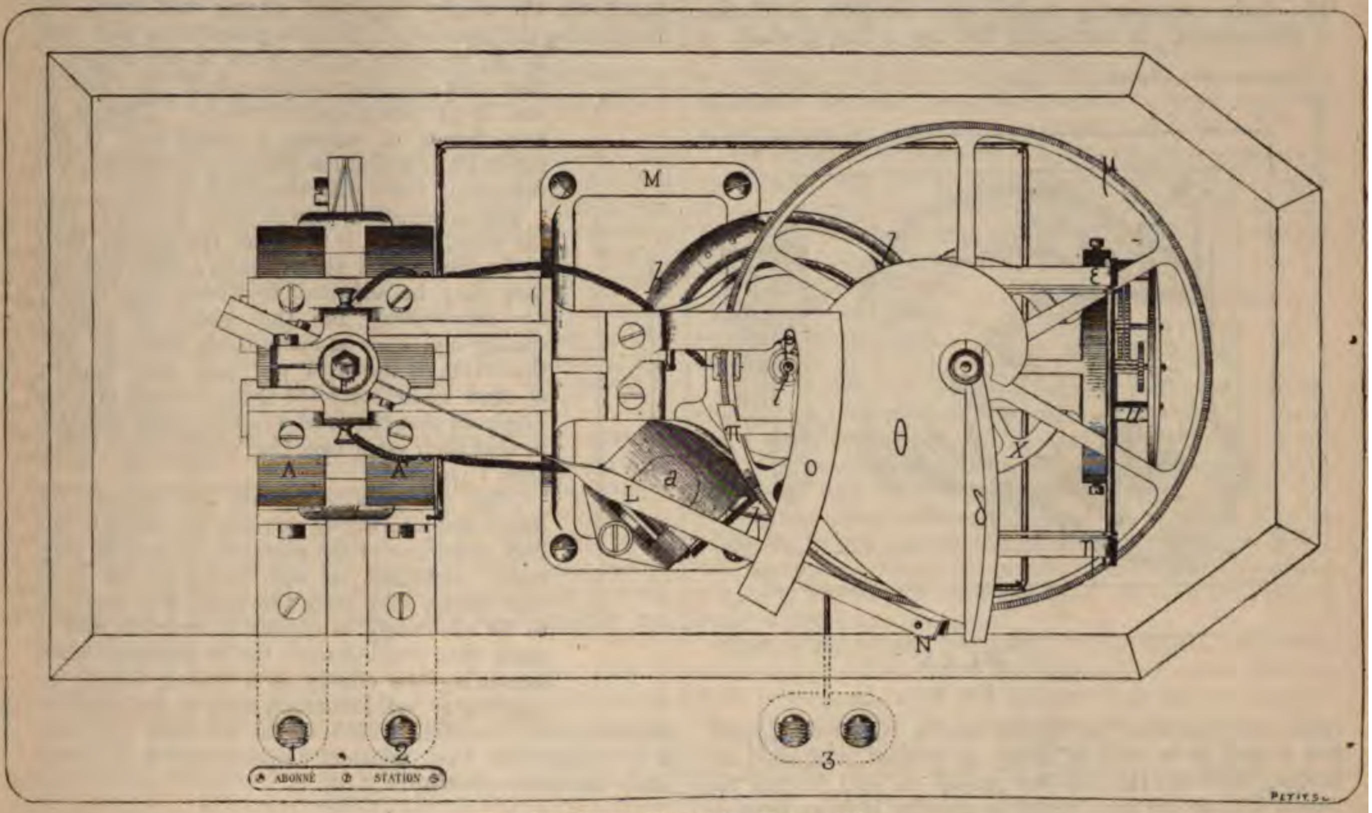


Fig. 1.—Frager Electricity Meter. Plan.

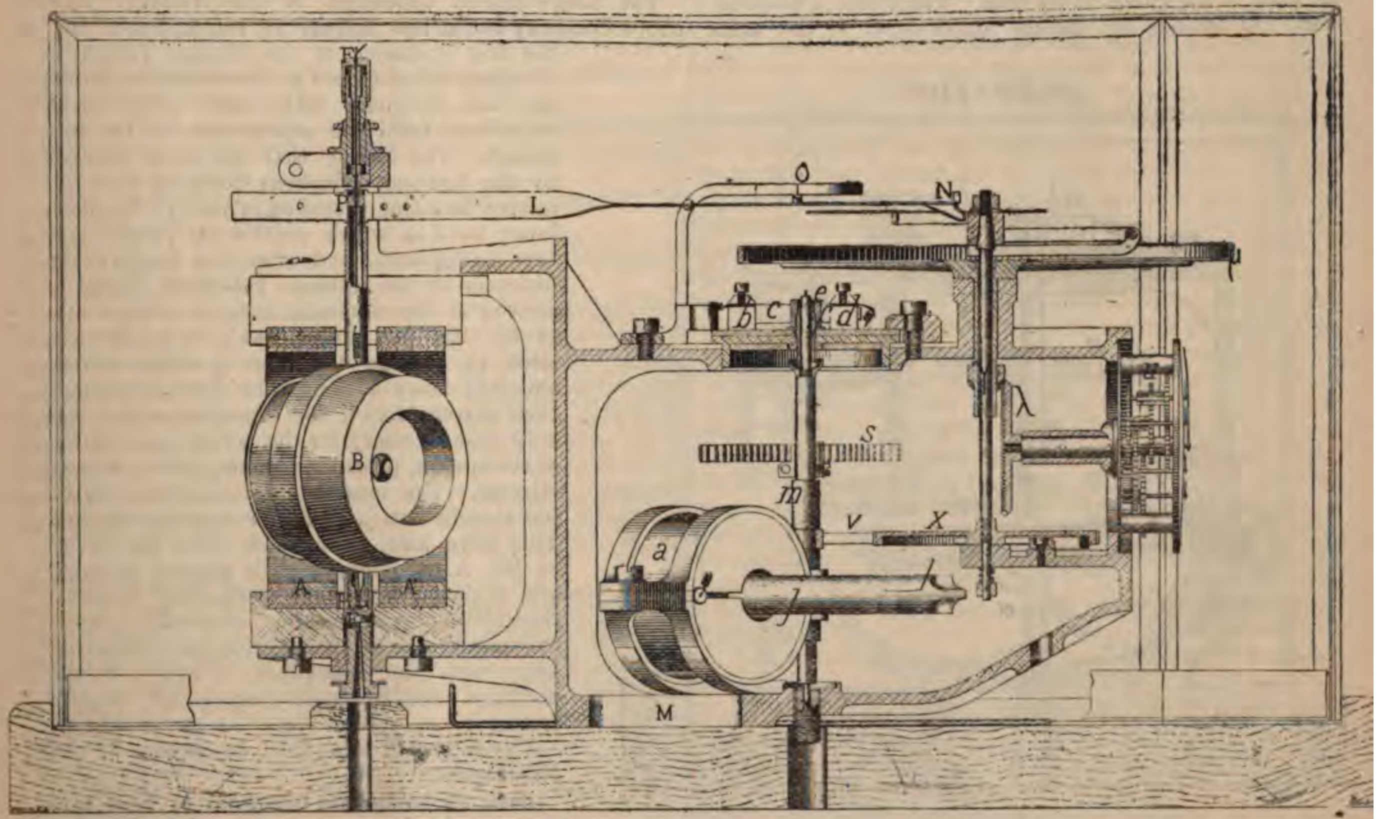
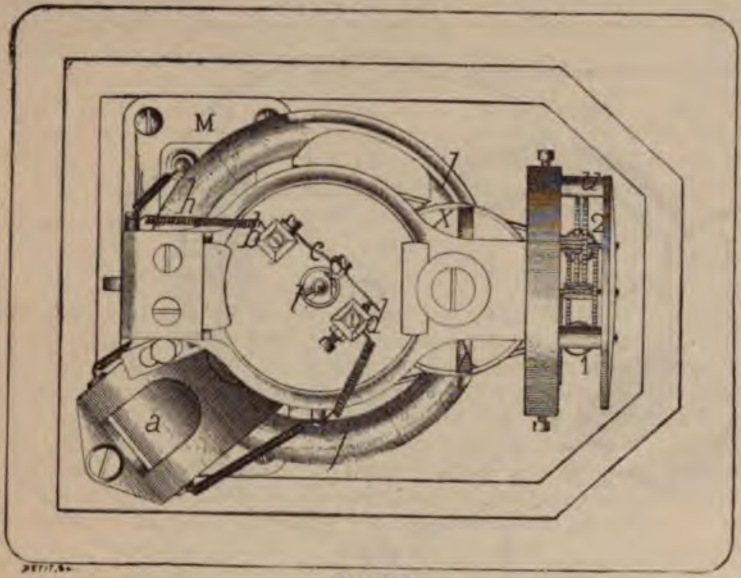


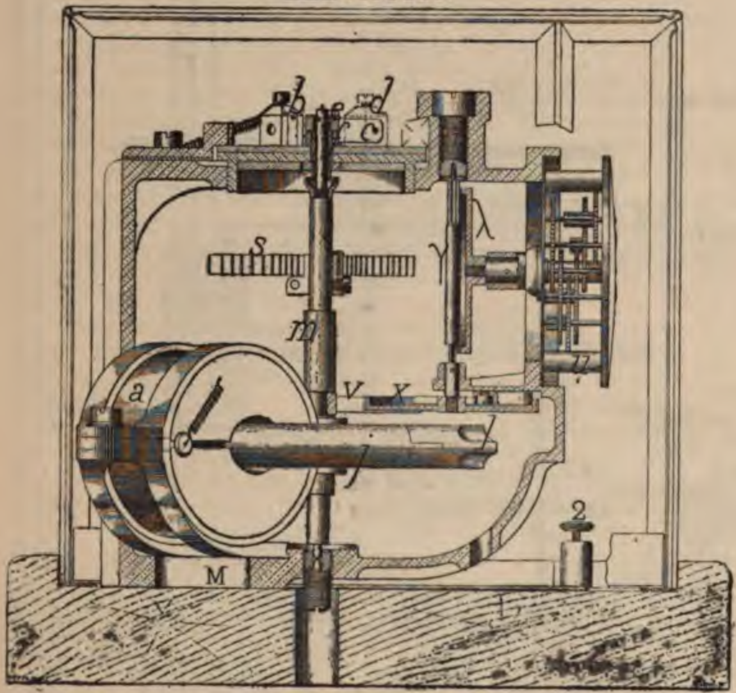
Fig. 2.—Frager Electricity Meter. Elevation.

ment is ready to start again. The motor coil is also connected in parallel with the lamps. The motion of this pendulum is communicated to the shaft, γ, by means of the eccentric, *v*, and the wheel of 100 teeth, *x*, which it pushes round one tooth every oscillation; this shaft consequently makes one complete revolution in 100 seconds. It carries at the top a bar, δ, which at each revolution lifts the flexible needle, N, whatever position it may be in, and, in doing so, presses it against the bridge, O; when the bar has passed on and is free the needle falls on the cam, θ, and in pressing it down from its horizontal axle, εη, the tooth, π, engages in the wheel of 600 teeth, μ, and continues to do so until the cam has travelled so far that the needle leaves it. The outline of this cam is such that for any position of the needle the angle through which the wheel, μ, moves is proportional to the watts in the circuit at the time. The wheel, μ, advances every 100 seconds an amount proportional to the watts indicated by the position of the needle at the instant when it is caught by the bar, δ. These individual impulses are added up, as it were, and communicated to the dials, through a train of clockwork suitable to the units chosen, by means of the bevel wheel, λ, and thus the increase in the readings on the dials in a given time denotes the energy expended in the circuit during that time. A large needle is fixed on the dial, which advances every 100 seconds a certain number of divisions. These divisions indicate in watt-hours the energy expended during that time. By multiplying the number of divisions passed over each time by 36, we arrive at the watts in the circuit, so that each division corresponds to 36 watts, or one 10-c.p. lamp approximately. This is an easy means of making a rough test of the meter by counting the lamps so registered, and comparing them with the lamps in use.



PLAN

Fig. 3.



ELEVATION

Fig 4.

The principal feature in these meters is that the error, if any, is the same throughout their entire range, and consequently, after one test they may be adjusted to within $\frac{1}{100}$ merely by substituting for the wheel, λ, another similar one with as many teeth, more or less, than 100, as the error per cent. may require, so that when corrected their accuracy is absolutely all that the most exacting could demand, in that their error over the whole range is less than 1 per cent.

They are equally suitable and accurate for direct and alternating currents, as, owing to the high resistance of the movable coil and its very small coefficient of self-induction, the error that might arise from this cause is so small as to be absolutely negligible in practice, and is more than overbalanced by its accuracy when measuring the energy in a circuit, having an appreciable self-induction, such as arc lamps or retarding coils, because, in such a case, the error per cent. in an instrument that registers amperes only is an absolutely unknown quantity.

THE MANCHESTER MUTUAL TELEPHONE COMPANY.

The long-expected opposition to the National Telephone Company has at last become an accomplished fact, the first exchange of the Mutual Telephone Company being opened in Manchester on Saturday last, February 28th, with results which more than fulfil the expectations of the promoters. The feeling that the rates charged by the National Telephone Company were excessive has long prevailed in view of the much lower tariff to which continental people have been accustomed, and after due enquiry the directors of the Mutual Telephone Company arrived at the conclusion that an average rate of £5. 10s. per annum would be amply sufficient to provide the best possible service, and still leave a profit to be divided amongst their shareholders if the capital expended was only that necessary for the actual construction of the system, promotion money being strictly tabooed. The rate they decided upon was £5 for shareholders and £6 for non-shareholders. They have also determined, under the advice of Mr. A. R. Bennett, their general manager and engineer, to prevent overhearing conversations by employing nothing but metallic circuits in connection with their exchanges; and to do away with the annoyance of delay at the exchange and through ringing off, Mann's system is employed.

The following is a brief description of the Mann system:

Each subscriber has two wires or lines connected to his instrument. One of these (called the Main Line) is for conversing with other subscribers only. The second (called the Signal Line) is for communicating with the operator only.

The signal line is brought into use by depressing (and keeping steadily down as long as required) the small lever which projects on the right-hand side of the instrument.

So long as this lever is pressed down the subscriber's instrument is in circuit with the signal line, and cut off from his main line. When the lever is allowed to rise by the finger being taken off it, the instrument is in circuit with the main line, and cut off from the signal line.

At the exchange, operators are continually listening on the signal lines; therefore no ringing is required to call their attention.

One signal line is allowed to about 60 subscribers. As a consequence, when two subscribers on one signal line chance, as will frequently happen, to depress their levers at the same moment for the purpose of giving instructions to the operator, they will hear each other's voices. But, as the signal line is reserved entirely for giving instructions to the operator, this does not imply that conversations between subscribers (which take place exclusively on the main lines) can be overheard. On the contrary, the greatest merit of the mutual system lies in the fact that conversations cannot be overhead.

The instructions to the operator consist of two or three words (see below) which occupy only about a second to deliver. Therefore if, on depressing his lever, the subscriber finds another already giving instructions, he has no appreciable time to wait. In such a case he keeps the lever depressed, and on hearing the operator acknowledge receipt of the passing instructions he can immediately add his own. Subscribers soon learn to follow each other rapidly and without interference.

The working of the system is so expeditious that an operator can receive, acknowledge, and execute instructions as fast as the subscribers can speak them. Nothing but the giving of bare and necessary messages is permitted on the signal wire, and operators are forbidden to enter into any conversation. Should a subscriber have anything beyond the usual instructions to communicate to the exchange, he must ask to be connected to the chief operator, who will speak to him on his main line. A feature of the system is that a subscriber can tell by means of his bell that his instructions have been carried out. When his main line is not connected to another subscriber's, his bell will not ring when he turns the crank. The moment his bell rings in response to the turning of the crank he knows that the connection asked for has been made, and that his correspondent's is also ringing.

Conversely, he knows when he has been disconnected from another subscriber, for then his bell will not ring when the crank is turned.

The instructions issued at Manchester for working instruments are as below:

"In giving instructions use numbers only. Operators are strictly forbidden to accept names.

"To call another subscriber, take the receiver off the fork and place it to your ear. With your finger depress the signal lever (projecting from the right-hand side of the instrument), and keeping the lever firmly depressed, as distinctly as possible, call out first your own number, and then that of the subscriber you want with the word, 'On' between. Thus, if your own number is 400 and you want No. 60, you say, '400 on 60.' On hearing the operator say 'Right 400,' you remove your finger from the signal lever, thus allowing it to rise; hang the receiver on the fork and turn your crank.

"The moment your bell rings it is a sign that the connection has been made. Give your crank three or four brisk turns after your bell has commenced to ring, then take the receiver off the fork, place it to your ear, and wait for your correspondent's answer, which, if he is attentive, should come immediately. Tell him your name; ask (to prevent mistakes) 'Who are you?' and then proceed with your conversation. When finished, depress the signal lever again, and giving your number, say 'Off'—thus, 400 off.'

"When, after concluding a conversation, say with No. 60, and another connection is required at once, say with No. 730, depress the lever, and call out '400 off,' and then immediately '400 on 730.'

"*To Answer a Call.*—When your bell rings, take the receiver off the fork and enquire 'Who is there?' When finished, depress the signal lever, and, giving your number, say 'Off'—thus '400 off.'

"*Remarks.*—When calling another subscriber, if your first ring does not produce an answer, you must hang up your receiver and ring again.

"It is necessary to remember that the receiver must be on the fork when you ring. When it is off the fork you can neither ring nor be rung. It is also necessary to remember that the signal lever must be kept firmly depressed when speaking to the operator.

"In the event of a connection not being got promptly, you can always call the operator by depressing your signal lever. In doing so you must always mention your number. The operator has no other means of identifying you from any of the other subscribers on your signal line.

"The number of each subscriber's telephone is posted on the instrument thus:

MUTUAL TELEPHONE
NO...................
MANCHESTER.

"Both caller and called should be sure to depress the signal lever and call out his number and 'Off,' after finishing a conversation. If this is not done the operator will leave the two lines connected, and a third subscriber asking for either may be told that he is engaged. When you depress the signal lever and speak to the operator, it is not necessary to call out 'Hello,' or enquire, 'Are you there.' The operator is always there and listening, and you have simply to depress the lever and speak through your instrument without any preamble."

Such is the system given effect to in Manchester. The transmitter employed with the present instrument is of the Bell, or magneto, type, and the best that can be supplied until the expiry of the Edison transmitter patent on July 30. The establishment of an efficient exchange prior to the expiry of the Edison patent in July was more than doubted by many. The National Telephone Company's directors especially scouted the idea, but this opinion was based on want of knowledge of the capabilities of the Bell telephone, when constructed specially to act as a transmitter. The German Government, as is, perhaps, not sufficiently well known, employed nothing but magneto transmitters on their exchanges for nearly eight years, microphones only being fitted in 1887. The instruments employed by the German Government were manufactured by Messrs. Siemens Bros. and Co., Limited, and the same firm was commissioned by the Mutual Telephone Company to manufacture transmitters specially for them. The result at the opening of the exchange at Manchester on Saturday was proved to be most satisfactory, for the Siemens transmitters, in conjunction with the metallic circuits and an improved receiver that the Mutual Telephone Company have adopted, proved to be so extremely efficient that the speaking on the "Mutual" exchange was at once recognised by the subscribers to be already considerably superior to that obtained on the National Telephone exchange by means of the Blake transmitter. A carbon transmitter of greater sensitiveness will be substituted in August, when it may be expected that a really ideal exchange will be at the service of Manchester, and the sooner we have something like it in London the better. It is a noteworthy fact that the Mutual Telephone Company already have orders for 2,000 exchange lines in Manchester alone. They have been extremely fortunate in obtaining wayleaves, and it is expected that in the course of a very few months their exchange in Manchester will be larger than that of the National Telephone Company.

Athens.—The mystic lamp, burning without oil or wick, seems to thrive at the classic city of Athens. After a year and a half there are 3,838 incandescent lamps supplied, besides 82 private arc lamps and 52 public arc lamps and eight motors, of a total capacity of 50 h.p. During the month of December last the station supplied a total of 200,000 ampere-hours. The gas company now put in fittings free of charge, to keep up with the competition. A large number of the public buildings are now lighted by electricity, and the demand is constantly increasing.

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

THE STRAND.

"The Strand is up again," was the phrase used by a gentleman to us, in a tone of injured innocence, as if he was personally injured thereby. No doubt the breaking up of one of the main arteries of traffic is a nuisance, and causes a tangible loss to shopkeepers, though the loss may be recouped by subsequent advantages. The breaking up of the roads for purposes connected with lighting is recognised as a necessity. The object of local authorities should be to reduce the inconveniences to a minimum. Enquiries, with a view to ascertain the action of the London County Council, prove that that body needs sounder advice than it at present gets. Unless our information is incorrect, the present breaking up of the Strand is for the purpose of laying larger mains through a distance of between four and five hundred yards. The Council have, in the interests of the users of the street, stipulated that the work should be commenced and finished within 14 days. This task may be possible, but it is difficult, as not only have the electric light people to do their work, but the gas workers have to take up one of their old and now unused mains. It is again stipulated that the work shall be commenced at both ends, and it is this stipulation that seems to us open to most objection. It will cause a double block in a busy street—in fact, block the total length all the time unfinished, and make the regulation of traffic more difficult than if only one block took place. The time during which the street is up may be shortened, but if the view above taken is correct, the inconvenience during the period while work is carried on will be considerably greater than if the work was carried on only at one point. In streets where the traffic is not so great it may be convenient to carry out the work by having half a-dozen gangs working towards or from each other, but what is permissible in one case is injudicious in the other. At first sight it seems as if less inconvenience would be caused by working from both ends, but when considered in connection with the enormous traffic the result is doubtful. At any rate, those who should understand the matter are almost unanimous in their opinions. Electrical engineers who have to carry out the laying of mains in streets, are fully sensible of the anathemas hurled at their heads; and would be glad if the authorities would more closely examine the possible result of stipulations before making them, rather than find out afterwards that a different course would have been preferable.

SOME STATISTICS.

It would be interesting if some of the Post Office officials would, amongst the mass of statistics given in Blue-books and reports, make a calculation of the year's saving to the nation owing to the introduction of telegraphy. Fifty years ago, and later, the Government maintained a semaphore signalling system between London and Portsmouth. The annual upkeep of this one line was stated, in a return made to the House of Commons in 1843, to be from £3,000 to £3,500. The signals were available only about 1,600 hours during the whole year. We should like to know the number of words sent by the Government over this semaphore system during a year. The cost per word could then be ascertained. The number of words sent over the telegraph lines between London and Portsmouth during the past year might be given, and the cost of such sending. The cost per word for telegraph messages would thus be known, and the comparison of cost per word could be given, or we could know the total cost to send by a semaphore system. A good many criticisms of costly Government are heard and seen, but few people realise that in many directions an enormously increased amount of work is done now, at a greatly lessened cost, than was possible even 50 years ago. In fact, had not invention come to the aid of civilisation, neither business, population, nor comfort could have progressed so rapidly as they have done. The development of electrical application in all directions has been and is one of the greatest factors in modern progress, yet those who would fain push forward further developments are met with so vast an amount of inertia as often to render their efforts futile.

ALTERNATE CURRENT TRANSMISSION.

During the third and the last of this series of Cantor lectures at the Society of Arts, Mr. Gisbert Kapp dealt very fully with the probabilities of transmission of power electrically by means of alternate currents. The limits of transmission by direct currents is reached when it is necessary to employ two or three thousand volts pressure, and therefore future development will probably—nay, must—be in the direction of alternate currents. In a most graphic and admirable manner Mr. Kapp described the position as it exists. He showed how Ferraris first of all pointed out the right way to get an alternate-current motor that was self-starting, and how Tesla and others had worked in the direction indicated by Ferraris, and, finally, how a three-pole alternate-current motor had been produced that would start, keep in step, and also pick up again though momentarily overloaded. He showed how this was done with the use of—not two—but three line wires to the motor. But the most interesting point was that Mr. Brown, of the Oerlikon Works, was now constructing an alternate-current plant whereby to transmit the whole of the power required by the Oerlikon Works. Here the power will be transmitted from Bulach to Oerlikon, a distance of 15 miles, under a pressure of 25,000 volts. This installation of Mr. Brown's will be watched with the greatest interest throughout the civilised world, for upon its success will depend the introduction of similar plant in many districts where natural water power must be transmitted over considerable distances, if it is to be rendered serviceable to the inhabitants. We have not thought it necessary to give abstracts of these lectures of Mr. Kapp, because they will ere long be published fully in the *Journal* of the society, and when complete can be better discussed than from mere abstracts. Still, the experiment to be made at Oerlikon deserves the widest possible notice, in order that those interested in the subject may know where to obtain information.

COST OF ACCUMULATOR TRACTION.

The recent fierce discussion that has taken place—more perhaps in private than in public—over the cost of accumulator traction should lead to eventual dissolving away of useless speculation, and to the bringing to light of the solid and valuable nugget of real facts about the cost of accumulator working for which the electrical profession has had to wait so long. It is to be hoped that authoritative figures will ere long be given, so that we may know exactly where we stand in this important problem. It is some time now since we were able to announce, as we were authoritatively informed, that a definite arrangement had been made by which sets of accumulators for a certain number of cars, say, 20, were to be maintained by the makers for a definite price of 1d. per car mile run. This itself would at once put the matter on a definite footing, and—notwithstanding the suggestion that the depreciation would be more than this, and that the makers would only have to stand the loss—we are at liberty to believe that some such arrangement could be satisfactorily and advantageously made. The deterioration in the cells results principally from three causes: burning out of the connections, mechanical shaking of the plates, and over-discharge. The first is a matter that slight alteration in manufacture—for instance, the use of copper embedded in lead connections—will obviate. The second—mechanical shaking—is, in reality, we believe, from actual facts before us, not so deleterious to properly-made cells as has been given out, and by far the most difficulty results from over-discharge. The excess of current taken out of the batteries with heavy loads on steep gradients and round stiff curves, rises to something over 300 or 400 per cent. of what it ought to be, and the continued occasional over-discharge wracks the cells far more than the mere shaking of the cars will ever do. This is the fruitful cause of the large depreciation known to have been experienced with some cells. Now, it is the merest truism to say that this over-discharge is not an electrical problem at all. It is, like so many other initial difficulties in electrical work, a mechanical one. The batteries ought so to be arranged with respect to their motors and gearing that no over-discharge of anything like this amount should be ever possible. The problem to be solved, as the merest tyro in traction should know, is this: How to overcome the greatest possible load in starting on the greatest incline on the given line; and the cells should be proportioned to this effort at the rate of discharge given by the makers, and should never be exceeded. It is clear this can only be done by suitable variable gearing connecting the motor to the car axles. Mr. Radcliffe Ward has been one of the earliest of the inventors who have tackled this problem for electric traction; and Mr. W. W. Beaumont, who is another, has produced a most ingenious variable gearing. If we are ever to achieve economical accumulator traction, attention must be given seriously to this part of the subject—gearing to prevent overload of the storage cells; then, and not until then, will the question be finally solved.

MORE AMUSING THAN A NOVEL.

[The following unique criticism appeared in the last issue of our contemporary, the *Electrical Review*. It is so amusing that ordinary practice may for once be suspended, and we may venture to give further prominence to the criticism and the reply thereto.—Ed. *E.E.*]

"First Principles of Electrical Engineering." By C. H. W. Biggs. London: Biggs and Co.

This is a work professing to deal with electrical engineering. If the preface should by any mischance be taken seriously, it will undoubtedly cause dismay in the heart of many a writer whose efforts have hitherto been accepted as worthy expositions of elementary electrical science, and whom, indeed, the author with elegant directness and empty egotism characterises as "fools." We, however, nervously heave a sigh of relief after the author's intimation that "there is very little in the book that will clash with the views of workers like Crompton, Hughes, Hopkinson, Kapp, etc.;" and, further, that "there is no attack or disparagement meant in regard to theorists like Sir William Thomson, Clerk Maxwell, Professors Lodge, Rowland, etc." How thankful we are to receive this modest declaration after observing how far the author goes out of his way to vilify writers of all the elementary text-books!

This is a book in which there is much cry, but little—dreadfully little—wool. We are told, in effect, that it will not deal with the "thoughtless iteration of Thales," but with the supplying of a "working foundation to students whose hope is to become practical men"; presumably, from the title, electrical engineers. Yet, will it be credited, a large portion of it is taken up with considerations of frictional electricity—the Wimshurst machine, Leyden jar, condensers for telegraph working, tangent galvanometer, Daniell, Grove, and Leclanché batteries, elementary propositions in graphic statics, etc., all of which will be found treated in a much clearer and much more reliable fashion in many of the well-known elementary text-books denounced by the author in such unsparing terms, as "the sooner their contents are forgotten the better." The construction and action of arc and incandescent lamps are, however, left undescribed, and there is not a single decent detailed illustration of a complete practical dynamo, transformer, secondary battery, or volt and ammeter, or any illustration whatever of an electric motor.

The book is *full* of mistakes (far more mistakes than there are pages), not only in regard to printer's errors, bad English, and careless revision of proofs, but also in regard to first principles and well-known data. In fact, should a beginner read this book before he has studied any other on this important subject, he will find it difficult to recover from the many erroneous impressions thus first implanted in his mind. Let it, however, be put into the hands of an advanced electrical engineering student, and he will find it far more amusing than any *novel* he ever read, for on every other page he will have the pleasure of detecting the most outrageous and flagrant errors ever printed since electricity became a practical science, and he will close the book with a feeling of wonder and amusement at the assurance of the author in having issued such a crude, careless production. He will, in fact, agree with the concluding remarks of the author's preface, that should it not realise what is required it "had better be burnt by the common hangman than put into the hands of students."

Just to observe one or two of the many hundred mistakes in the book, we find at page 133 the following statement: "Taking that every pound of coal consumed in the furnace of the boiler should give 10,000,000 heat units, what part of this energy is obtained in the working circuit as given by the formula $C^2 R$?" This must be "Heaven-born" coal! Or, perhaps Mr. Biggs has just returned from the infernal regions, where the everlasting fuel employed by his Satanic majesty never dies out! Any ordinary British engineer is only too glad if he obtains little more than $\frac{1}{1000}$th of the above-mentioned calorific value applied to his boilers.

In many places the author confounds between work, energy, and power—*e.g.*, at page 96, he says, "the watt (unit of work?) = volt × ampere (C × E) 746 watts = one horse-power." At page 78 the text is quite unintelligible when compared with the accompanying figure, for the all-important letters, N, S, and R, are omitted. Besides which the author is entirely wrong in asserting that the maximum E.M.F. is generated when the armature coils of a dynamo are moving *parallel* to the lines of magnetic force between the poles of the dynamo!

We withhold further remarks, in view of the magnanimity shown by the author of the book in letting Sir William Thomson, Clerk Maxwell, Hopkinson, Crompton, and others off so very cheaply!

CRITICISING THE ABOVE CRITIC.

To the Editor of the "Electrical Review."

Sir,—May I venture to ask a small space to criticise the critic of my book? I am delighted at the criticism. It is a very creditable performance, and just what might be expected from the pen of the ultra orthodox. The only mistakes to be found are (1) in the method, and (2) in the matter. The former is a kind of shadowless echo from Mark Twain and Artemus Ward. The spirit undoubtedly was willing, but, alas! the brain was weak. My preface seems to dominate all else in the critic's mind; it is the Alpha and Omega of his criticism. May I parody an "Amurican" jingle for the benefit of your critic:

"The *Electrical Review* was asked, Can you suggest a cure
For the debilitated state of certain lit'rachure?
'Ain't none—the author's ignorance is far too dark for lightnin';
While I who know enough to write hain't got no time for writin'."

I would also like to quote for his edification a sentence from Locke, for no doubt, as my critic makes so great a point of grammar, he must be well acquainted with the English classics at any rate—"He that will not eat till he has demonstration that it will nourish him; he that will not stir till he infallibly knows the business he goes about will succeed, will have little else to do but sit still and perish." It is amazing—to your critic; it is astounding, it is condemnable—still to your critic; that the author of a pettifogging little book should have the audacity to think for himself and say so many things that are unorthodox—and therefore wrong. It may be still more surprising to your critic to find that I, at any rate, look upon his criticism as the greatest compliment he could have paid me. Like Balaam, he came forth to curse, but the curses are blessings in disguise. Let us see The views expressed about induction are unorthodox. Has the critic shown they are false? My views as to the use of + and − differently in the external and in the internal parts of the circuit are unorthodox. Has my critic ventured to tackle me on this point? My views as to the constancy of action of a "line of force," and of the "pull of a magnet,' are again altogether unorthodox, but my critic has not ventured to expose the idiocy of my views. So far as orthodox and heterodox views are concerned, the book professes to be heterodox, but the reviewer simply says it is *full* of mistakes and altogether wrong. Of course, from the orthodox view it is; it was intended to be. He fights shy of the heterodox problems, and shines in questions of grammar and lost letters in illustrations. One would naturally imagine that while filled with the divine afflatus—query, inflatus—he would have selected the most vital errors to damn the book. Yet what does he do? He gives three examples. One a stupid blunder, but clearly indicated by the context to be a blunder—where "10,000,000 heat units" is printed instead of "10,000,000 foot-pounds," and no engineering student would be misled for a moment. Another heavy charge is that certain letters are missing in a diagram. This is awful, because, of course, the whole thing is so exceedingly difficult that they must be known to make the reasoning clear. Unfortunately, to support the reviewer's contention, the reader must be unable to say which is his right hand, for the book says N is the right-hand pole. With regard to the third grave charge, I am right, and your reviewer suffering from the hysterical condition consequent upon the nightmare of the preface which weighs so heavily upon him, cannot have weighed the evidence to the contrary of what he states. This champion printer's reader shows clearly that he looks, as he should in such character, for "literals," and misses the sense of what he reads. He has just said that at p. 78 *the text* is unintelligible without certain letters. It may surprise readers to learn that the figure he refers to is *not* mentioned on p. 78 at all, though the figure itself is placed there. The text is on p. 79. The error is not worth mentioning except that those who grovel in the dust with a microscope should be quite sure they are right. To return to the charges. On p. 78, which he must have looked at, I find "the action in the conductive circuit is proportional to the number of loops or closed curves of lines of force," etc. On p. 79, I read "When the conductive circuit, R, is in a *vertical* position the maximum number," etc.; further down, on p. 79, "T is now at the bottom, B, and has now the maximum number of loops around it"; further on still, on p. 79 and turning over on to p. 80, "The number of loops increase till the circuit is vertical." Again, on p. 80, "the number of loops that pass around the conductive circuit, as this determines the electrical pressure and consequently the current." On pp. 81, 82, and 83, the same strain is continued; see, again, p. 106 (by the bye, on p. 107, your critic will find the letters "ere" missing). I might also refer your critic to pp. 114, 115, 116, 117, 154, 155, etc. May I venture to quote again p. 155, "The numbers of lines looping the coil being fewest, practically none when the coil is *parallel* with the lines, and largest when at *right angles* to the lines." I could say much more, and, perhaps, to the point, but as I ask for criticism, not from a proof reader, however great an adept he may be, but from one who knows something of electrical engineering, I refrain from pursuing this point further.

Now, Sir, if your printer's reader wants to show more of his proficiency, please let him put a tag at the end of this after the following fashion. On p. 3 "symmetrical" is twice wrongly spelt; on p. 13 is an "o" wrong fount; in other places an "l" is missing, or an "i," or "nd," or "oil," and so on—dozens of errors; show that "I" is used instead of "me," "it" for "its," an adverb for an adjective, that a comma is misplaced, etc. This kind of thing will amuse him and won't hurt me. As yet he has shown a lion's heart combined with a baby's fist. If he really has got anything to say worth hearing, for heaven's sake let him take up my challenge on page 121 about the use of + and −. A discussion on this point will be such as all can understand. There are some other points I dispute your reviewer's ability to discuss, as he is evidently not fully acquainted with the subject. Still, if he desires it, I have no objection to hear him upon the "unit line of force," the variability or the non-variability of the action or actions of a line of force. The time for the hangman is not shown to have come by calling attention to missing letters and evident misprints. It is my intention to reprint all critical remarks with my comments thereon, as indicated in my preface. This will make a pamphlet equal to a shilling shocker.—I am, yours faithfully,

C. H. W. BIGGS.

Saving Oil.—In engineering workshops 75 per cent. of the oil remaining in the metal cuttings from drilling and planing machines can be recovered by a suitable centrifugal machine. The gain in recovered oil is about 40 to 45 gallons per ton of cuttings.

CORRESPONDENCE.

A TERM WANTED.

To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Pray do not charge me with "doubting modern advances" (p. 214). I have heresies enough to defend in doubting whether some fashionable modern theories or hypotheses are advances at all. Marking time looks like marching and makes a great noise, but it can hardly be called advancing. It does seem to me that what are called modern views amounts to this: We know electricity and magnetism only as shown in iron, copper, guttapercha, and so on. We do not know what goes on in them. Instead of finding out what does occur, and waiting humbly for an explanation till we know, let us suppose that the phenomena really occur in something else, which, as no one can contradict, because neither we nor they know anything about it, we can endow with any properties we choose, and change them at pleasure. There we have "the ether"; if it has such and such properties it will explain the phenomena we do not understand: therefore it has those properties. Then we begin at the other end of the chain; the ether, because it has such and such properties, is the cause of certain phenomena which present themselves in matter, and fully explains those phenomena. Then, of course, we promulgate the *cuicunque vult*, and declare doubters unorthodox and heretics.

I have for some time past been trying to manufacture a "term" for the fundamental fact of electricity, but have not produced a satisfactory word; energule would unite energy and matter, and would submit to change as noun and verb, etc., but does not sound quite pleasant. Till such a term is adopted, much confusion of ideas must continue, because the word electricity embraces phenomena and their causes, and two distinct sets of both. It has a relation to matter, and properties which are like those of matter; yet it is quite certain that its most important actions are not those of matter, but of energy. On the other hand, it has been abundantly proved that electricity is not a form of energy. It can be clearly comprehended as the action of energy through the atomic structure of matter. So the term wanted is one which shall express the marriage of matter and energy, and be limited to that conjunction. In fact, we have the analogy of water currents to complete: there we have the material basis, water; we have also the energy conferred by pressure; we express them both in the word hydraulics; we do not confuse the work done in an engine driven by water power, the stream of water led to the engine, and the original source of power in one word, and that—water; but this is just what we do in electricity, with endless confusion of thought as the result.

If that twofold nature of electricity had been clearly kept in view by means of a distinctive name, I think more attention would have been directed to the real operations, and we should have heard nothing about the mysterious functions of ether. If it had been clearly realised that there is in all respects (except the production of magnetism) an absolute identity between the electric current and the hydraulic current, we should never have heard of the notion that the electric energy travels by an outside medium, and that the conductor (absolutely essential) conducts nothing, and is a mere waste-pipe to get rid of energy, which is found to be a nuisance in the ether energy stream. How long will it be before some self-ordained prophet proclaims that what we call energy is the ether, and that ether is the unknown "substance" which we know under the form and accidents of matter?—Yours, etc.,

JOHN T. SPRAGUE.

CANTOR LECTURE

To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—In your last issue the secretary of the General Electric Power and Traction Company, Limited, at the request of his managing director, publishes a correspondence, in which it is stated that the Tables 4 and 5 of

Cantor lecture given by Mr. Kapp at the Society of Arts on Monday, the 16th ult., are entirely misleading, etc.

Now, Table 4 shows the cost of the equipment of the Barking-road line with half-a-dozen 52-passenger accumulator tramcars, carried out by the writer in the spring of 1889 for the Electric Traction Company, Limited, every item of which is accurate, and their details can be furnished, the amount being £6,191. 16s. (see *Electrical Engineer*, February 20). The cars proper are not included in the table, as only those items connected with the running expenses are dealt with. To include the cars would add £1,200 to the total, making it £7,391. 16s., which is, perhaps, not what is desired.

Table 5 gives the running expenses for the full mileage of the line—*i.e.*, five cars in service, running a total of 100,844 miles per annum, being 8·068d. per car mile. This corresponds to the year ending June 30, 1890. It is accurate. It must also be very nearly true, indeed, for the present time, since the five most important items—namely, batteries, wages at depot, drivers, steam plant—remain unchanged, and these five items represent 88 per cent. of the total. The life of the batteries is 10 months, or 300 discharges up to the present time. The cars have now been on the road 21 months, and are working with their second renewals. It is to be hoped that the K-type plates may prove more durable. The end of the present year will show their merits or demerits as compared with the ordinary type.

It is to be observed that the 8d. per car mile corresponds to the full mileage of 100,844 miles per annum, and that the wages at depot are a fixed charge—£677. 6s. a year. The mileage run during the first half-year of 1890 under the charge of the writer was 44,047 car miles, the mileage run during the second half-year (the installation now becoming the property of the General Electric Power and Traction Company, Limited) was 33,794 car miles, or a decrease in miles run, period for period, of 10,252. Is this a measure of the improvements? This low mileage runs up the proportion of shed wages from 1·612d. to 2·405, making the car mile run 8·861d., which is unpleasantly near to 9d.

I must remind Mr. Mackenzie that I left the Electric Traction Company, Limited, at the time of its liquidation, and was in no way connected with the company to which he is the secretary.—Yours, etc., T. Frazer.

114, Broadway, Plaistow, E., March 3, 1891.

ELECTRIC RAILWAYS.

There is little doubt that if electric railways can be made successful undertakings from a commercial point of view—and there seems to be no reason why they should not—the close of the present century will probably mark a considerable extension in their use in Europe. That such railways can be operated satisfactorily is demonstrated by the working of the City and South London Railway during the past three months. If the working expenses of this undertaking do not exceed the ratio of operating expenditure to gross receipts on steam railways—and it is possible that they may be less—and assuming that the present weekly number of passengers carried is conveyed throughout the first year's working, the City and South London line should be a commercial success. However, whatever may be the ultimate results, the fact that the railway can be and actually is worked in a satisfactory manner, has attracted considerable attention both in the United States and on the Continent; and the outcome of this is the conception of several similar projects.

On the Continent three schemes have been advanced. The first is the construction of a level electric railway to connect Vienna and Budapest; the second an underground electric railway in Antwerp; and the third an elevated line in Berlin. The first mentioned railway was to have been built at a cost of 3,800,000 florins, and was to have been financed by the Budapest Commercial Bank. Arrangements were made for an inspecting committee to come to London to inspect and examine the working of the City and South London line, and the Hungarian Minister of Commerce was approached with a view to the granting of a concession to establish the railway, the trains of which were to have been operated from six generating stations along the proposed route. Unfortunately for the promoters, and possibly fortunately for the reputation of the electrical profession in the present stage of electric traction, the Hungarian Minister of Commerce refused last week to give his consent to the carrying out of this gigantic scheme; and there the matter terminates for the time being.

The second project, which has just been advanced in Belgium by a Liege syndicate, headed by Baron Sadoine, the well-known director of the Cockerill Works, comprises the construction of two tunnels under the River Scheldt so as to connect Antwerp with the left bank of the river. One tunnel would be built for a steam railway, whilst the other would contain an electric railway. The river is very wide at the point at which the tunnels would be built or laid, and they would be constructed so as not to interfere with the navigation of the river; the draught of the large Red Star Line steamers frequenting the port being a maximum of 28ft. The proposed electric railway is attracting more attention than the steam line.

The third scheme refers to the construction in Berlin of a southern electric railway between the Silesian Station and the Zoological Gardens Station. The Ministry of Public Works have had under consideration for ten years a project for the building of a railway to connect the south-eastern, south, and south-western portions of the city, and to form a connecting link between the Ringbahn or circle railway, and the Stadtbahn or town railway. For some reason or other, the line has never been established, although the need of it has been long experienced, and there do not appear to be any great difficulties in the way of carrying out the scheme. Now, however, Councillor von Siemens, in conjunction with other promoters, has elaborated a scheme for the construction of a high-level electric southern railway to supersede the proposed steam line. This electric railway would comprise a double track, would be carried overhead on standards, and passengers using the Ringbahn or Stadtbahn would only have to walk a short distance to arrive at the electric railway. The railway would cross the River Spree by means of a bridge just above the Oberbaum Bridge, and the trains would travel equally as rapid as those on the town and circle lines. This scheme is to be considered by the Municipal Council and it will also be submitted to the Minister of Public Works, whilst the Antwerp project will be referred to the Town Council.

UNDERGROUND MAINS.—V.

THE BROOKS OIL INSULATION SYSTEM.

This system, the invention of Mr. David Brooks, of Philadelphia, embodies the use of heavy mineral oil—one of the best of insulators—as the dielectric for high-tension underground mains. The system has recently been brought prominently to the front in this country by Messrs. Johnson and Phillips, the representatives of Mr. Brooks in this matter on our side of the Atlantic. The system has, however, been well known for many years, and has received much favourable commendation, in this country from no less an authority than Mr. Preece, and in America numerous experts have testified to its efficiency, and dating back as far as 1877, in which year Mr. Brooks laid some experimental wires in Philadelphia.

In 1887, a line of 1⅓ miles was laid by Mr. Brooks on the Pennsylvania Railroad. In this cable there were 18 splices and 53 conductors, and a very high insulation value was obtained, and an important feature in reference to telegraph and telephonic circuits was practically demonstrated—viz., its low inductive capacity, which in this case gave a mean value of about ·212 microfarads per mile.

The experience in America of over 10 years, though almost exclusively telegraphic, amply demonstrated the permanence and efficiency of the system. Mr. Brooks claims in reference to these circuits that while other multiple cables have frequently broken down and developed faults due possibly to lightning and other causes, that his circuits have never given way, and continue to this day to give values as high as when the lines were first put down.

In the earlier experiments Mr. Brooks employed ordinary fluid mineral oil as insulating medium. This, however, was found to have a very high penetrating power, and continual care was needed to keep the oil confined. The oil now adopted, produced from the waste products of rosin oil, is a thick sticky mass less liquid than treacle, and has the advantage of being extremely cheap.

Practical details have now been carefully worked out, and it may be confidently stated that the Brooks system, well carried out, has the best claims of permanency and efficiency of any underground high-tension system, and that it will probably contrast favourably as to cost with any other system of anything like similar insulation and permanency.

The dielectric is a pure homogeneous thick fluid of extremely high insulation value. It does not oxidise when exposed to the air, and when occupying the whole of the space in an iron pipe beyond that occupied by the conductors and their fibrous covering, possesses all the elements of permanency—in fact, theoretically the system seems to exclude all the ordinary factors of decay, and the permanence of the system seems only limited by the life of the containing pipes, which, in ordinary cases, we believe have been known to last over 20 years when used for gas or water, where it must be remembered both the inside as well as the outside of the pipe is exposed to influences tending to cause decay; whereas in the Brooks system it is evident that no decay of the pipes could go on from the inside, and any deterioration that took place would be limited to the oxidising and perishing process from the outside only. Hence it is urged with much show of reason that the Brooks system must rank well, not on the score of insulation alone, but on that of permanency.

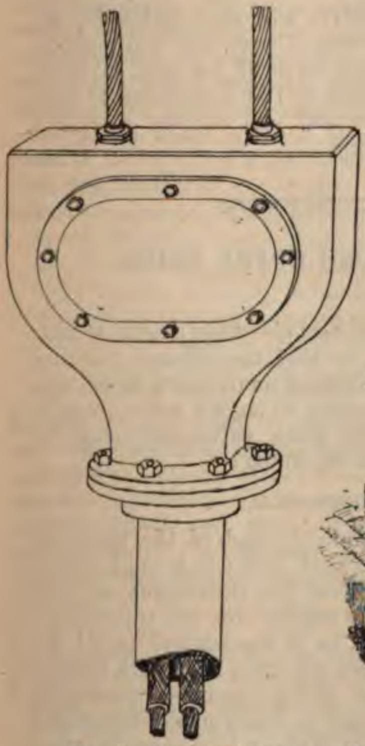


FIG. 3.—Terminal Box.

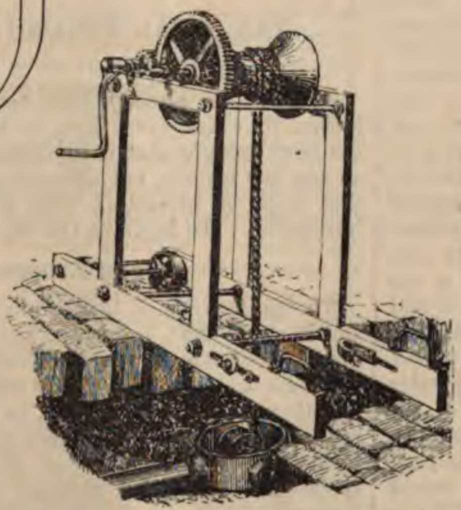


FIG. 6.—Winch for Drawing in Cables.

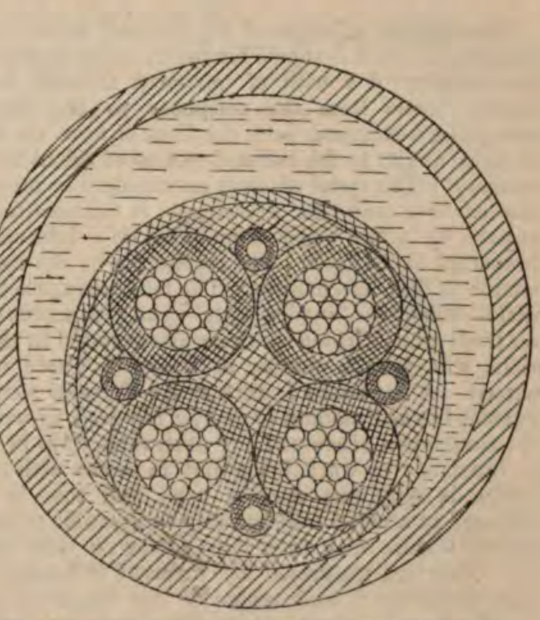


FIG. 4.—Section of Underground Mains, with Oil Insulation.

The mechanical details of the Brooks system are seen in the accompanying cuts, larger details of which will be given next week.

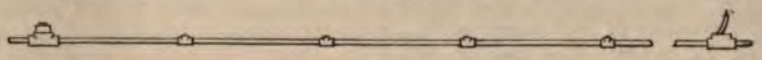


FIG. 1.—Brooks System of Underground Cables in Iron Pipes.

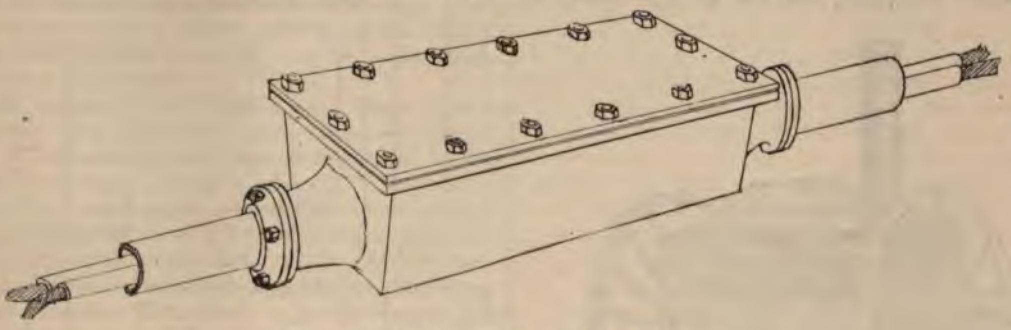


FIG. 2.—Drawing in Box. Brooks System.

The iron pipes are used in the usual lengths made and kept in stock, and have their ends carefully bell-mouthed, and connected together by T-sockets, as shown in the small cut, Fig. 1, and at suitable distances draw-in boxes, Fig. 2, are provided, which may or may not have glands for the cables to pass through, according to circumstances. Branch circuits are taken off by means of junction-boxes fitted at points determined upon. The junction-boxes are in all cases provided with glands for the cables to pass through, so that the fluid dielectric may be removed from the junction-box for the purpose of making a branch connection, or for testing purposes, the glands then preventing the dielectric from flowing into the box from the pipes containing the mains.

The branch connections connected thereto are preferably lead-covered cables of the ordinary type, which also pass through glands. The junction-boxes may also contain fuses between the branch circuits and the mains. The terminals are formed of cast-iron boxes of special form provided with glands with suitable vulcanite sleeves, through which the ends of the cables are brought, Fig. 3. At the highest point of the line a tank or cast-iron box with removable lid is provided, which is occasionally examined and kept charged with the fluid dielectric, so as to ensure the whole system being fully charged. A small trench having been dug and a section of the line having been prepared and all joints in the pipes carefully made, the cables, which consist of ordinary stranded copper conductors, covered to a suitable thickness with raw jute or hemp strand, preferably by braiding, and again wound over all with a sewing of braiding, are coiled on drums and placed in a tank of the fluid dielectric and carefully heated up to about 300deg. F., and maintained at this temperature sufficiently long to drive off all moisture. The cable may be of suitable size, and composed of varying number of strands; that shown in section, Fig. 4, consists of four cables of $^{19}/_{13}$, with four pilot wires of No. 12 gauge. The end or ends are attached to a hauling-in strand of wire or rope previously passed into the pipes, and the cable is drawn in direct from the hot dielectric, Figs. 5 and 6, by means of a winch.

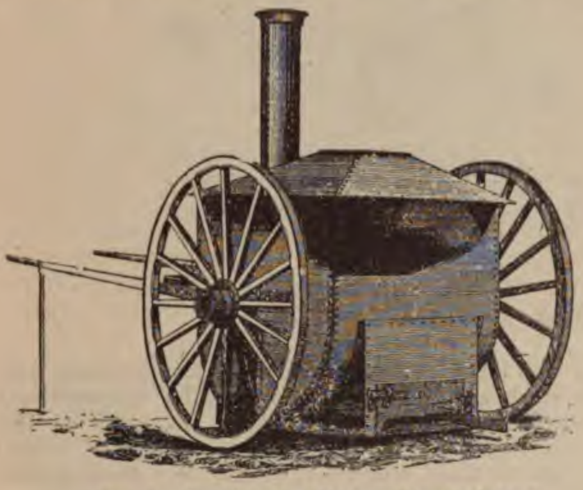


FIG. 5.—Cauldron for Heating Brooks Cables.

(To be continued.)

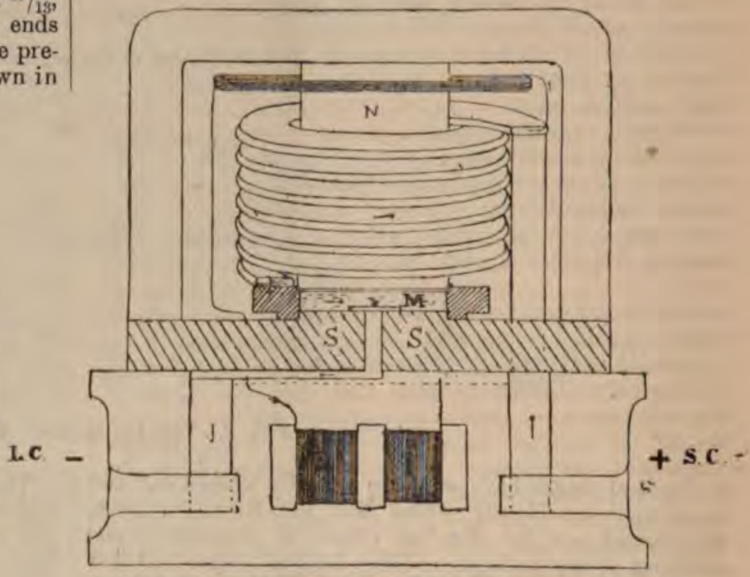
FERRANTI ELECTRICITY METERS.

The essential principle of the Ferranti meter (a sectional diagram of which is shown herewith) is the measurement of the rotation of a bath of mercury through which the current passes from the periphery to the centre after energising a magnetic field, the lines of force of which are at right angles to the radial direction of the current in the mercury. The speed of rotation increases in proportion to the current, and the movement is transmitted to the register by a fan which is mounted on a light spindle and immersed in the bath. The registering of the meters is as simple as their mechanism. The faces are marked with six dials—units, tens, hundreds, etc.—and the amount registered on these when divided by the constant stated in the instructions, will give the number of Board of Trade units consumed. A important feature of the Ferranti meter is the extremely small amount of energy required to work it, and the consequent absence of any observable drop in volts, due to resistance or work being put in series with the lamps. There is only one moving part, and this is perfectly enclosed in a metal case, entirely inaccessible to any of the defects a more open form must sooner or later be subject to. They are unaffected by external influences; indeed, the correctness of their record is not impaired (as would be the case in some other direct-current forms) by a magnet being placed near them, as might be done by a dishonest consumer.

They are, in brief, motor meters of the simplest attainable form, and as such do not require to be touched for winding up or recalibration. They are made entirely of uninflammable material, can be quickly installed and connected, and are suitably designed to prevent their being tampered with afterwards, unaffected by external influence.

As regards accuracy, a great disadvantage of some other forms of meter is their inability to start registering at a small fraction of their full load, that is to say, when the friction of the working parts is greatest relatively to the force to overcome it. A consideration of the design of the Ferranti meter will show that in it this friction is at a minimum, but even so far its effect is largely reduced by a simple and effective device, the "compensating coil," which is the patent of the makers.

This device consists of a fine wire coil (in some sizes of direct-current meters the residual magnetism of the field is arranged to take effect and the fine wire coil is dispensed with) through which a minute shunt current passes round the iron core and produces a strong magnetic field relatively to the small current passing through the bath at low readings.



M shows the Mercury Cup. L C indicates Lamp Circuit.
S C indicates Supply Circuit.

By this means Ferranti meters will start registering at about 1 per cent. of their limits of load, and will register with less than 3 per cent. error over 97 per cent. of their working range—*i.e.*, for instance, a 100 ampere-meter will start registering at 1 ampere, and will register correctly from less than 3 to 100 amperes.

THE ROYAL ENGLISH OPERA HOUSE.

So much has already been said about the degree of perfection to which everything in this magnificent building has been brought that it is, perhaps, unnecessary to enlarge on any one feature, but electricity so largely contributes to this state of perfection that some particulars may be interesting. To begin at the beginning:

THE ENGINE-ROOM.

The engine-room is situated in the back of the building, and is about 20ft. below the road level; it is built with a double roof, which extends over the boiler-room, so that the noise and vibration of the engines are not transmitted to other parts of the house, or if transmitted at all are reduced to a minimum. There are three Marshall's boilers, locomotive type, known as 30-h.p. nominal, producing steam at 140lb., fed through a Berryman's feed-water heater. There are also three Willans high-speed engines of 135 h.p., coupled direct to the dynamo, and running at 350 revolutions per minute.

The foundations of these engines are built up independently, and are not part of the engine-room floor, so that vibration in the house is still further reduced. The main steam-pipe passes over the three engines and the boilers, all of which are in a straight line, and is tapped off on to each, so that in the feed-pipes there is no bend whatever.

The exhaust steam is utilised for a multiplicity of purposes. It passes through three feed-water heaters, the first of which supplies the boilers, and the other two supply hot water to the lavatories, etc., in all parts of the house.

What steam remains is used to warm the building, by means of an ingenious arrangement of pipes, through which the steam passes, and circulating round which is a strong current of air forced through by means of a Verity's silent air propeller, coupled direct to and actuated by an electromotor. The steam generated is thus used to the utmost, and the exhaust steam-pipe which runs to the top of the building has a great deal of spare time on its hands; in fact, most of the steam ultimately finds its way, in the form of water, into an open pit about 50ft. or 60ft. deep, through which the whole of the water is drained by means of two pumps—a Worthington and a Pulsometer.

Dynamos.—Each dynamo, with its engine, is bolted on to one bed-plate, and has a clear space of 4ft. all round. Two light overhead travellers are so arranged along the length of the engines and dynamos that they may be easily taken apart for repairs if necessary.

These three dynamos are Siemens new type shunt-wound machines, each capable of giving 650 amperes and 110 volts at 350 revolutions, and are all connected to the main switches in the engine-room in parallel. Any two of them are capable of doing the whole load, and the third one is always in readiness, and is kept moving *slowly* every evening for a short time to see that it is in order. Each dynamo has a pilot lamp across the terminals. The regulation of these machines is entirely done by means of a hand resistance in series with the fields, and the stop-valves are left full open all the time. The E.M.F. is shown by a Cardew voltmeter with a 12in. dial, a gigantic needle, and figures that may be read at the other end of the engine-room with ease. As is the case in nearly all theatres, the load is subject to great variations, and in this particular opera the load varies some eight or 10 times in the evening from 1,400 to 300 amperes.

In addition to the spare dynamo and engine, two sets of 54 31L accumulators have been provided to supply light to the front of the house in case of any serious accident to the machinery, but they can be used for any circuit should it be necessary. They are arranged in three groups of 36 cells each when being charged, and are charged by one of the dynamos at 100 volts during the daytime, and are used for a short time every day to keep them in good condition. These cells have very commodious quarters of their own in a separate room, which is thoroughly ventilated, and they are so arranged on shelves that anyone of them can be got at without the least difficulty. The ventilation of the house, as well as engine-room, boiler-room, etc., is done electrically in the following way: Fresh warm air is forced into each tier in six places on the walls through air channels by the air propeller referred to above, and each ceiling is supplied with large gratings communicating with other channels leading to a chamber in the roof containing another large air propeller electrically driven, which carries away all the bad air, and makes room for the fresh supply. A third motor and fan fitted in the top of the dome also contributes to the ventilating arrangements. In the engine-room the ventilating fan is fixed at the end opposite to the boilers, so that all the bad air is forced into and carried away by the furnaces, and fresh air supplied in its place; this arrangement was necessary, as it would have been impossible to ventilate the engine-room into the street.

THE STAGE.

On the O.P. side of the stage there is a very complete system of bells and speaking-tubes to all parts of the house, made by Messrs. Adams and Co. These tubes are all put in a large case, and are arranged so as to return to their places when released after use. In the middle of this bank of tubes are four push buttons, which serve to set the artificial thunder in motion. The use of electricity to produce thunder is most appropriate.

To return to the electric lighting arrangements. Above and to the right of the bells and speaking-tubes is a platform for the accommodation of the man in charge of the lighting.

In front of this platform is a large case containing a pair of Cunnington patent fuses for every circuit in the house. Underneath this case are fixed all the switches; and below these, again, the levers for regulating the resistances in the stage lights.

Of the four pairs of main leads from the dynamos, three go direct to the stage, and one pole only of the fourth goes straight into a room entirely devoted to the resistances used for all lamps throwing any light on the stage. These resistances are all of bare platinoid wire mounted on porcelain insulators.

The lowering and raising of the lights is done by means of a series of small wheels supplied with handles, fitted independently on an axle running through them all. The hand wheels communicate by means of endless wire ropes with switches, which control the resistance by short-circuiting some of the coils in circuit. The method does away with all sparking, and if the switch should get out of order it does not put the light out, but merely introduces all the resistance into the circuit. A large lever at the end of the axle enables all the lamps in the building that are supplied with resistances, taking a little one 1,000 amperes to be raised or lowered simultaneously, while the independent hand wheels can be utilised to vary any desired combination. The limits of variation are from 110 to 50 volts.

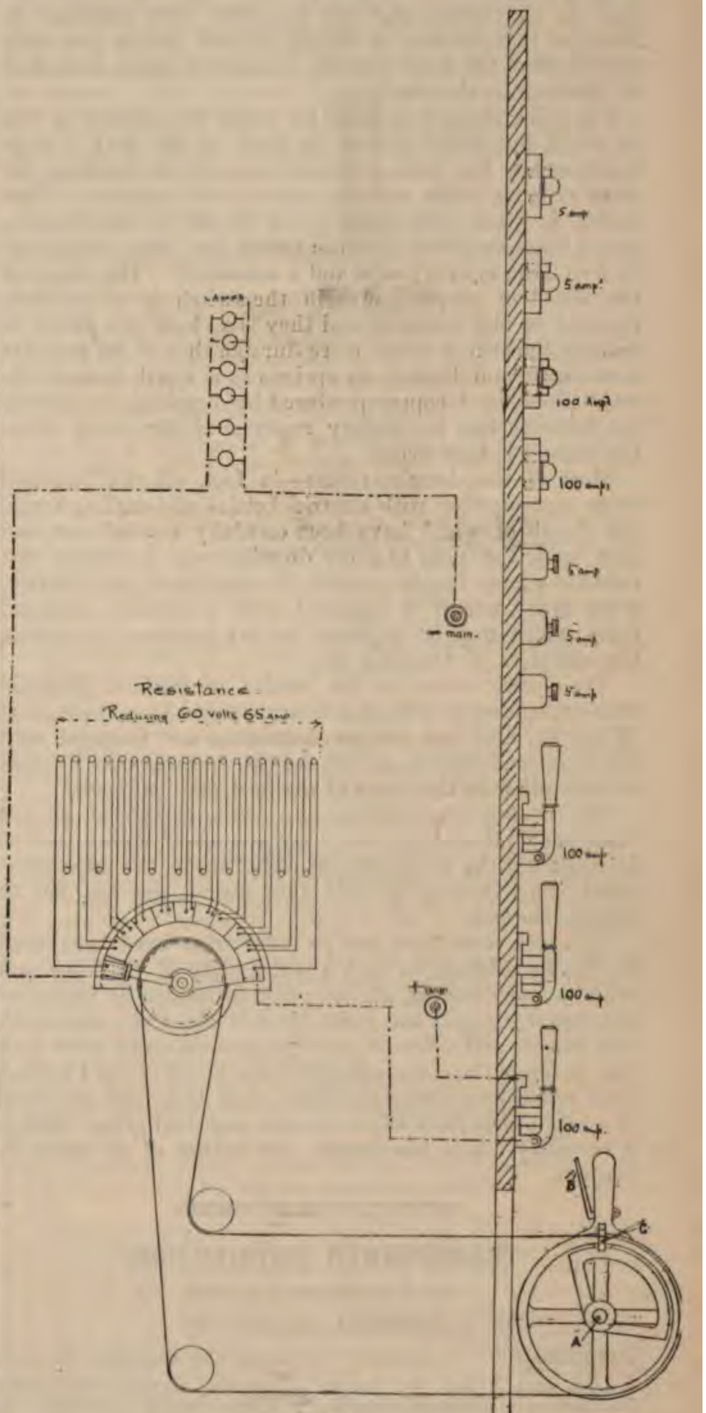


FIG. 1.

The accompanying sketch, Fig. 1, shows diagrammatically the arrangement of the fuses, switches, and resistances.

All the levers for controlling the resistances are mounted loosely on the main axle, A, and may be moved independently by pressing the handle, B, and liberating the tooth, C.

The room devoted to the resistances is also thoroughly ventilated.

The battens, of which there are seven, are all wired in three circuits, and can consequently be fitted with red, blue, and clear lamps if required, as is the case with the hand battens for the sides. These hand battens contain 36 lamps each—12 blue on one circuit, 12 red on another, and 12 clear over on the third—and are provided with switches so arranged that the man in charge of each batten can vary the colour of the light himself, or they can all be controlled by the man on the platform.

For quick changes of scene for which the curtain is not let down, but which have to be done in the dark, a large main switch has been provided, capable of breaking the main circuits while running with 1,400 amperes. This switch is fitted with copper gauze blocks to take the arc, and is short-circuited after the circuit has been completed by two large mercury cups and a connector. The object of the blocks of copper gauze in the switch is to facilitate renewal of the contacts, and they also have the effect of making the switch much more durable than if the contacts were made and broken on springs as is usual, because the small globules of copper produced by breaking the circuit are flattened into the spongy material of the gauze when the contact is next made.

Most of the dressing-rooms—in fact, all the principal ones—are supplied with electric kettles and curling tongs, the details of which have been carefully carried out, and just inside the door of every dressing-room is a switch that controls a lamp for the general illumination of the interior, while every mirror is supplied with a suitably arranged lamp, which may be adjusted to any position to facilitate the operation of "making up."

The electric stoves for the kettles are made of platinoid wire embedded in cement and surmounted by a thick sheet of copper, and the kettles themselves are supplied with thick copper bottoms, so that the two surfaces may lie close to each other so that none of the heat may be wasted.

The curling-tongs heaters are made somewhat on the same principle, except that they are made hollow, and to be made hot the tongs are put right inside, the heat generated being limited, so that they cannot get too hot to damage the hair.

Although electricity and its accessories have been used in this installation for such a multiplicity of purposes and with so much success, all its possibilities are by no means exhausted; but, at the same time, if the stage managers, and lessees, and actors of past generations could come back and examine the completeness of this house of the Pierides, they would be gratified to think that they had not lived in vain in that their efforts in the past had given birth to a necessity which has become the mother of so much invention.

TRANSFORMER DISTRIBUTION.*

BY J. SWINBURNE, MEMBER.

(Continued from page 216.)

PARALLEL RUNNING ACCORDING TO ARMATURE REACTION THEORY.

Last year I had the honour of reading a paper before this Institution on armature reactions in direct-current machines. In it I showed how the performance of large machines could be foretold; and the whole question of the effect of the armature current on the field magnets was discussed with some minuteness. I cannot pretend to treat alternate-current machines with the same exactness, but still a great deal is to be derived from the study.

It has sometimes been assumed that a machine has self-induction in the armature, and also that there are armature reactions to be considered, and the two actions are treated as if their joint effects had to be taken into account. This view is, I submit, erroneous. Imagine a battery with its cells connected to a number of contact-pieces, and imagine the middle cell connected to a terminal, to represent one terminal of the machine, and the other terminal represented by a rubbing contact which is moved backwards and forwards over the cell contacts by a crank and connecting rod. This gives the analogue of a hypothetical machine with no self-induction. If a choking coil is put in circuit, the hypothesist's alternating machine would be produced. To get a constant coefficient of self-induction in a real machine would be almost impossible. If a coil passes between two cheeks of laminated iron, its coefficient of self-induction is constant. In a dynamo, however, half the iron is cut away, the remainder forming the pole-pieces, and this remainder is not laminated. Even if a dynamo gave a curve of sines at no load, therefore, the reasoning already given would not be accurate, as L would vary considerably from one part of the period to another.

The term "self-induction" is also used somewhat loosely. Engineers do not generally think of electrical inertia now. By a self-induction 1 in an electric circuit is meant that if there is a current of 1 in it, it is interlinked with one line of induction. The idea of self-induction is naturally inseparable from the notion of magnetic induction being interlinked with the circuit. Another way of looking at it is to say that if the current increases there is a back E.M.F. proportional to the rate of growth of the current, and to the self-induction of the circuit. In an alternate dynamo the first definition is meaningless, because there is a field produced by the magnets; so, when the machine is still, there may be a large number of lines of induction through the armature coils without any armature current. If the second definition is taken, there is likewise an E.M.F. produced by the passage through the field, apart from the effect of the armature current.

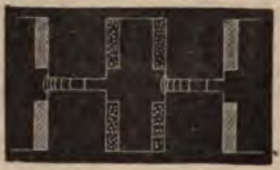


FIG. 3.

Take the case of a machine like the Siemens, with coils passing between poles. If there is a continuous current in the armature, in some positions it will assist the field magnets, and in others it will to some extent weaken them, while in intermediate positions it has no effect on the magnets as a whole. In an alternate-current machine, though the armature current is alternating, relatively to the field magnets it is direct. If a series of instantaneous photographs of the armature current could be taken, each part of the air space would have its direct current.

Fig. 3 is a diagram of the field-magnet poles of a machine. There are supposed, for simplicity, to be twice as many pairs of poles as there are armature coils. If one side of a coil is between each pair of poles, if there were no armature current the fields would be inducing a maximum pressure. If the pressure curve of such a machine were traced, and placed in the diagram of the poles, it would be as shown in Fig. 4. The positive direction of the current or pressure in the armature and field-magnet coils is shown by shading, the negative by dotting. If electricity flows in the armature when the sides of the coils are in the active fields, one side of the field between the poles is strengthened and the other weakened, as shown in Fig. 3. This action is fully explained in the case of direct currents, in my paper already referred to; but in alternate machines the action is much more complicated, for there is no longer a continuous succession of conductors each carrying the same current as it passes any given position. If the pole-pieces were laminated, the distribution of field would vary as each conductor passed; but as it is not laminated, Foucault currents developed in the pole-pieces tend to check variations under influences varying from 200 to 600 per second. The field thus becomes stronger on one side. The curve of pressure thus gets displaced, as shown in Fig. 5.

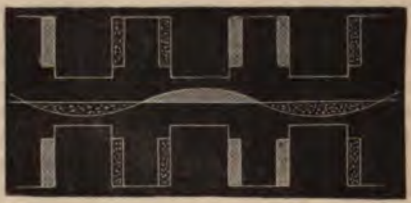


FIG. 4.

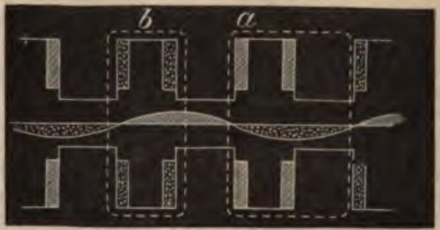


FIG. 5.

If the external resistance is non-inductive, this may be regarded as a current curve. It will be seen that each magnet is now exposed to the back induction due to the armature current. A circuit, *a*, taken round the field-magnet circuit is interlinked with the whole wave. The line integral is not changed if it is taken round any other circuit, so that the sides are the same distance apart as they are in *a*. A circuit taken as shown at *b*, however, includes only half a wave; so that from Fig. 5 both the cross and the back induction could be completely worked out. In most machines it is impossible to make such a diagram accurately; but in others, such as drum armatures, with poles and coils of given widths, it is not so complicated.

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* *Paper read before the Institution of Electrical Engineers.*

The effect of the armature current, then, is first to make the current lag relatively to the position of the field magnets, and then to lessen the pressure as a whole. It thus resembles the effect of the insertion of artificial self-induction.

I think to call all this "selt-induction," and to assume the harmonic law just to make calculation easy, is disguising the real nature of the action, and may lead to very serious errors. The armature reaction theory is also infinitely easier to understand, and to follow in one's head. The result of it is, in short, that if the current lags, the field is weakened; if it leads, the field is strengthened. If the current is in the direction agreeing with the E.M.F. of the machine, it tends to lag, owing to cross-induction; if it is against the E.M.F. of the machine, as in the case of a motor, it tends to cross-magnetise the fields in the opposite direction.

We may now examine the question of parallel running from the armature reaction point of view. Though it may be out of its proper place in the paper, the question of motors may be to some extent discussed at the same time.

Suppose, as in the first case, a pair of terminals in connection with a station, so that the E.M.F. on them is independent of any current, or the machine under discussion connected to them. It is necessary to keep clear for the moment of any ideas connected with L. The armature circuit must be regarded as devoid of "self-induction."

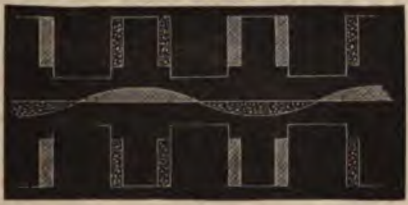


Fig. 6.

A machine without friction may be imagined, and when its field magnets are separately excited, so as to give an E.M.F. exactly equal to that of the mains when it is connected so as to be in step, it runs as a motor taking no current. At each instant the E.M.F. of the machine is exactly equal to the E.M.F. of the mains, so no current passes. On putting on some load the machine begins to lag. As soon as the machine lags, a current passes through the armature. The current due to the difference of two equal alternating E.M.F.'s is not in step with either of them. This is shown in Fig. 6, where two pressure curves are drawn a little out of step. The current through resistance is proportional to the shaded parts. If the E.M.F. of the machine were still the same as that of the mains, it would still develop no power as a motor, because at some parts of the period it would be supplying power to the mains, and at other parts the mains would be supplying power to the armature; for at any instant the armature current would be equal to the difference of the two E.M.F.'s divided by the resistance of the armature. The average current curve is shown in Fig. 7. The

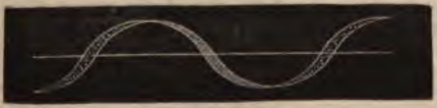


Fig 7.

E.M.F. of the machine does not, however, remain equal to the main E.M.F., merely differing from it in phase, but is decreased by the reaction of the armature current on the field magnets. The average current curve shows that there would be considerable back induction, or many ampere-turns tending to weaken the field. This weakening of the field by the armature reaction allows the main also to supply a current against the E.M.F. of the machine, so that it acts as a motor, and power can be taken from it. If the load is altered, the machine will increase or decrease its lag, so that its effective field is reduced to just the right value to allow the machine to absorb electrically the power taken from it mechanically. As lag is necessary in order to weaken the effective field, so the current in the armature is no longer in step with the E.M.F. of the mains. The result of this is that it is not at the maximum value at the same instants as the E.M.F. is; so that the power taken by the motor is less than the product of the effective E.M.F. of the mains and the effective current of the machine. The E.M.F. and current may be so much out of step that the power of the motor is small, though the armature current is large. The availability of the machine as a motor thus depends on the resistance of the armature, and on its reaction on the field. For instance, if the machine has very little armature resistance, a very small reduction of its E.M.F. will allow a large armature current to pass. If, on the other hand, the armature resistance is high, the armature must have a large reaction on the field so as to reduce the effective E.M.F. If, at the same time as the load is put on the field of the motor is artificially weakened by reducing the excitation—for instance, by the insertion of resistance in the field circuit—the E.M.F. of the machine may be reduced enough to allow current from the mains to act in step with the main E.M.F. For instance, if the supply circuit is of 2,000 volts, and if an ordinary separately-excited 2,000-volt machine is connected, and excited so as to give 2,000 volts with the same frequency, and if this machine is loaded as a motor with 40,000 watts, or 54 h.p., it will lag until the field is weakened enough to let enough current pass to give the power. This current will be more than 20 amperes; but if the machine as a dynamo can give 20 amperes with the loss of 100 volts in the armature, due to the resistance, and if the machine is excited so as to give 1,900 volts on open circuit at the normal speed, and is then thrown into the circuit at an instant when it is in step, and a load of 38,000 watts, or 51 h.p., taken out, it will remain in step, for the E.M.F. of the machine is always just enough below the main E.M.F. to allow the right current to pass. The effective current is then 20 amperes. The main circuit thus supplies 2,000 volts and 20 amperes. Two thousand watts are lost in overcoming the resistance of the armature, and 38,000 are available at the pulley. The losses by friction and Foucault currents are here neglected for the sake of simplicity. In practice a little less than 51 h.p. would be obtained for external use. If the field has not been weakened by reducing the excitation, the effective current—that is to say, the root of the mean square of the current, or the current as measured by an electro-dynamometer—would be more than 20 amperes, so that there would be an extra loss of power in the armature.

If the machine is to be worked as a generator in parallel with the main circuit—that is to say, if it is to supply power to the mains instead of to take it from them—the same reasoning holds good. If the machine is excited so as to give 2,000 volts at no load, and is thrown into circuit at an instant when it is in step—if the engine supplies just enough power to overcome friction, there will be no armature current, as the E.M.F. of the machine will, at every instant of the period, be exactly equal and opposite to that of the mains. If the engine supplies just a little too much power, the machine will begin to lead, and an armature current will pass, which will strengthen the fields by reaction, and the machine will at some instant act as a generator, because its E.M.F. is now a little higher, as the armature current has strengthened its field. Similarly, if the steam of the engine were completely shut off, the machine would lag until it worked as a motor. If now the steam is turned on until the dynamo supplies 40,000 watts to the mains, the machine will increase its lead until the armature current strengthens the field enough to give the full output. The armature current must be out of step with the E.M.F. of the machine.

In the examples back induction has alone been considered, but the effect of cross-induction must also be taken into account. Cross-induction, in the case when the machine is working as a dynamo, makes the current lag. This weakens the field, and counterbalances to some extent the effect of the leading current, due to the pressures being out of step. A still greater lead is therefore necessary to make the machine work as a dynamo. Suppose, however, that the field excitation is strengthened to balance this back induction, as well as the loss by armature resistance—that is to say, suppose it is excited to give 2,000 volts, and 20 amperes on resistance, in spite of the armature reactions—it will run in step on the mains.

It is thus possible by altering the field excitation of such dynamos to make them work well as generators or motors on supply circuits. Instead of depending on the reaction of the armature to strengthen or weaken the field, the field excitation may be automatically regulated, so that the current and E.M.F. of the machine are always in step, or very nearly so.

Take first the case of a separately excited motor. The field magnets may have an additional set of coils, and these are put in series with the main armature current, which is redressed or rectified by a commutator. These coils are arranged so as to demagnetise or weaken the field as the current increases, so that it is not necessary for the machine to lag in order to take a large load.

The machine may be made to excite itself. In that case special exciting coils on the main armature are provided. These are connected with the circuit for exciting the field magnet. If a machine made in this way is used as a motor without a series demagnetising circuit round the field magnets, it begins to lag as soon as load is put on, and the armature current then reacts on the fields and weakens them. As the exciting coils now pass through the same field, this will also lessen the field excitation directly; and as soon as the field is weakened by the armature reaction, the ampere-turns round are also reduced, because the E.M.F. in the exciting circuit is lessened. A very small lag will thus weaken the field considerably, so that a large load may be put on without the lag being great enough to make the machine inefficient. A series demagnetising circuit may be used in addition. If the ampere-turns of the field magnet are not adjusted to the load with perfect accuracy, the machine adjusts itself by lagging or leading very slightly.

Machines with fields excited chiefly by special exciting circuits on the main armatures, and partly by series circuits, may be specially useful for working in parallel as generators. The series circuits are then arranged to magnetise instead of demagnetise. If power is applied to a motor instead of taken from it, it becomes a generator, and the direction of its main current is reversed, both in the armature and the series coils on the fields; so that a motor with a backward series circuit becomes a generator with a forward series circuit. If one machine when used as a generator begins to lead because too much power is supplied to it by its engine, its field is strengthened by the series circuits, and this increases the armature E.M.F. enough to make it give a large output corresponding to the power supplied to it. If machines excited from special armature circuits, without series circuits, are run in parallel, they will keep in step, because the least leading or lagging alters the field excitation.

The compound form is best, because the whole station will then supply the mains at constant pressure, if all the engines are mechanically governed for constant speed of one of them—that is to say, if the whole steam supply is regulated to keep the speed of all the engines constant, the engines taking the steam in proportion to their size. Instead of keeping the speed constant, an electric governor can keep the E.M.F. of the whole station constant. With alternate machines as at present commonly used, it is necessary to alter the field excitation by hand or by automatic gear. Such machines as those described have advantages corresponding to those of compound direct-current dynamos, compared with shunt or separately excited machines. The analogy between these machines and compound or shunt direct-current machines must not be used too far. In direct-current machines, the E.M.F. adapts itself by slight alterations of speed, and the armature reaction depends on the position of the brushes; in alternate machines, the speed is unalterable, and the armature reaction depends on lead and lag.

Prof. E. Thomson tells me that he has been accustomed to send out separate and series excited machines for working in parallel, and that they will work either with or without "equalising connections," such as are needed with direct compound machines. They also work well as motors, and so do the self-exciting machines with separate exciting armature circuits. He also finds the ordinary Thomson-Houston machines works efficiently as a motor.

(To be continued.)

COMPANIES' MEETINGS.

ST. JAMES AND PALL MALL ELECTRIC LIGHT COMPANY.

An extraordinary meeting of the shareholders of this Company was held at Winchester House, E.C., on Monday, at 2.30 p.m., Mr. Eustace J. A. Balfour, chairman, presiding.

The **Chairman** said that in proposing the first resolution—viz.: "That the capital of the Company be increased to £200,000, by the creation of 20,000 shares of £5 each, to be called preference shares, and to be entitled to a preferential dividend at the rate of 7 per cent. per annum on the amount for the time being paid up on such shares, payable out of the net profits of the Company for each year"—he need scarcely dwell on the necessity for an increase in their capital, as the terms of the provisional order under which the Company existed obliged them to extend their operations over the whole area of the parish of St. James. The Directors considered that the original capital ought to be doubled, and there were three ways in which this might have been done. By the creation of ordinary shares, of preference shares bearing a lower rate of interest than 7 per cent., or 7 per cent. preference shares, and they had adopted the latter course as being the best for the holders of the ordinary shares. The Directors intended to offer 10,000 of these preference shares to the ordinary shareholders in the proportion of one to two. He would call attention to an error in the report on this head (*vide* our last issue, p. 223, first column, last few lines of report). In the sentence beginning "referring to the notice," the word "now" should have been written "then," so as to read "then on the register."

Sir John H. Morris, K.C.S.I., seconded the resolution, and it was carried after some criticism of the course adopted by the Directors.

The **Chairman** then put the second resolution, which ran as follows: "That the articles of association before the meeting be adopted as the articles of association of the Company, in lieu of those at present in use as such." He explained that the primary object of the alterations was to enable the shares of the Company to be quoted on the Stock Exchange; they had also taken the opportunity of further remodelling the articles in order to make them work better. Amongst other things, the new articles removed the £1,500 limit to the annual remuneration of the Directors. The Company had not been brought to its present state of prosperity without an enormous amount of very anxious work, and he thought they might fairly claim that their labours, while rewarded with success, had not met with tangible reward in other directions.

The **Solicitor** (Mr. Sydney Morse) then explained the various alterations in the articles, and the resolution, which had been seconded by **Mr. Latimer Clark, F.R.S.**, was carried unanimously.

This finished the business of the extraordinary meeting.

The ordinary meeting was then held. The **Secretary** and **Manager** (Mr. James Strick) having read the notice convening the meeting,

The **Chairman** said: With your leave, gentlemen, we will take the report and accounts as read. The first resolution is that "the report and accounts of the Directors for 1890 be, and the same are hereby, received, approved, and adopted, subject to this alteration, that the word 'then' be substituted for the word 'now' in the fourth line of clause 14 of the report, and that a dividend of 5s. per share, free of income tax, be declared and paid forthwith on the 9,000 shares in existence on the 31st December, 1890."

Mr. Latimer Clark, F.R.S., having seconded this,

The **Chairman** continued: In moving the adoption of the report, there are a few matters which I am sure will be of interest to you—matters connected both with the past and the present condition of the Company. You may recollect that it was at one time the intention of the Directors to propose a scheme for the reconstruction of the Company. Owing to the enormous improvement in our position this has now become unnecessary. The original contract with Messrs. Latimer Clark, Muirhead, and Co. has been practically completed, and, as a result of placing our claim against them for decision by arbitration, we have received an award of over £1,800. I wish to take this opportunity of placing the credit of this fact where it is due—namely, to Colonel Francis. At the same time, even arbitration is a risky, and possibly expensive, resource. And although in this case we have been successful, I am still of opinion that to agree to a reasonable compromise would have been a sounder course to adopt. Owing to expressions of opinion at last year's general meeting, the Directors offered £7,000 (the unissued debentures) to the shareholders. This course was against their better judgment, they considering that it would be better if these debentures could all be held in one hand. Experience has justified their view, for had this been done these £7,000 of debentures would have been converted with the remainder. The Directors hope that the three shareholders who hold these debentures will see their way to converting them into ordinary shares, and it is partly for the purpose of inducing them to do so and partly to deal with the shares not yet on the register, that we wish to substitute the word "then" for the word "now" in the last clause of the report. With respect to the issue of shares in July last, the Directors found themselves, owing to the want of the support of the shareholders, in the position of either guaranteeing to subscribe £2,000 each, or seeing the Company in Chancery. I merely mention this as an interesting practical comment on a somewhat violent attack that was made on them last year by a small body of the shareholders. By a perusal of the accounts, it will be seen that the whole of the profit last year was made in six months, the greater part of it during the last quarter from October to December inclusive. The true profit for the last six months of last year represents for that period a dividend at the rate of 10 per cent. on £100,000, which is an amount largely in excess of the capital at the disposal of the Directors at any time during that period. I do not wish to prophesy, but I can put before you some figures which will, I hope, satisfy you as to our prospects in the future. The output of current during the last two months is considerably in excess of half the output for the whole of last year. The number of lamps wired at this moment is nearly seven times as many as on the 1st of January, 1890, and we have applications for over 10,000 more. The average daily revenue during the last week is not far off six times as large as the average daily revenue during January, 1890, and that although the days are longer. I think, if you will put these figures together in your minds, recollecting that this increase of business is on our original capital, and that it implies but a small increase of staff, that you will agree with us in thinking that you possess a most valuable property, and one likely to be remunerative. And the Directors feel that the results of the year's working have completely justified the course of this Company's business as foreshadowed by them. As negotiations for the purchase of a site in the northern part of the parish of St. James are proceeding, it is undesirable to enter into detail on this subject. The experience gained in the erection of the present station places us in a position of great comparative advantage with respect to the erection of new works, both from the point of view of economy and efficiency. We shall continue to follow the principle of the subdivision of engine power, the adoption of which has been one of the causes of our steady success; and we shall further develop this principle by connecting the new station with the old in such a way that in a case of necessity each can afford the other support. I wish again this year to thank the members of our staff for the admirable and energetic way they have worked, and I wish specially to mention our secretary and manager, Mr. Strick, and our engineer, Mr. Dobson. If any of you knew as much of them as I do, I am sure you would feel as strongly as I do that they deserve our best thanks.

The resolution given at the beginning of the Chairman's speech was then put and carried unanimously.

The re-election of the retiring Directors, Mr. Eustace J. A. Balfour and Mr. Latimer Clark, was moved by **Mr. Hodson**, and seconded by **Mr. Howard**, and carried unanimously.

Mr. Way proposed the re-election of the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., which was seconded by **Dr. Muirhead**, and carried unanimously.

In answer to a remark from a shareholder, the **Chairman** explained that Mr. Latimer Clark was not a member of the firm of contractors, but a director.

A vote of thanks to the Chairman and Directors closed the meeting.

TAUNTON ELECTRIC LIGHT COMPANY.

The fourth annual meeting of this Company was held at Taunton last week, Mr. W. H. Fowler presiding.

The report of the Directors, which was published in our last issue, was taken as read.

The **Chairman** said he was very sorry that the report of the Directors for the present year was not so satisfactory as former ones. The report fully set out the difficulties the Directors had met with, which to some extent had been unforeseen. It took a great deal longer to move from one place to another; it was necessary to do so, and they could not be blamed for the step they took. The accounts showed a loss on the year of £438. 17s. 5d.—that is, after paying 5 per cent. on the £3,000 debenture stock. He had made an estimate for next year, for the whole position of the Company hinged on the income and expenditure. At the present time, with the lamps they had got, and the supply given, they were earning at the rate of £1,500; that was without counting anything at all for new lamps. The profits on installations which they could reasonably hope to carry out he had put at £150. If they made anything like £150 by installation work, their profits on lighting could not possibly be less than £100—they ought to be still more. He had put the profits at one-third of the rents, and he did not think he was overestimating anything if he put their income at £1,800. On the expenditure side, they paid last year for apparatus and renewals £936; that included a large sum for fittings which had been installed. He therefore estimated that in the coming year renewals could be calculated at £400, which would include keeping the machinery in its present high state of perfection. That estimate was rather more than was expended in the year before, when they were at the old place, but the machinery was in better order than it was then. Wages and salaries he put down at £470, which he was informed was the actual amount that would have to be paid. For coal he had put down £500, having knocked off £88 from the figures of last year, when they had coal burning at both stations. He was anxious to overestimate, rather than to underestimate these items. The interest on debentures would be increased from £141. 11s. 4d. to £300 if the additional amount, bringing the amount issued up to £6,000, was subscribed for. This, with the other necessary expenditure, would show a total amount of £1,895 for the year. That showed in round numbers an expenditure of £1,900, against an income of £1,800, or £100 against the Company; and showing the amount of profit earned would pay 3½ to 3¾ per cent. on the debentures. That would be their position, unless, of course, they had a very large increase in the number of lamps, or unless they increased the rentals. There would be £200 to be divided among the holders of the £6,000 of debentures, which would mean about 4 per cent. He did not think they could make out anything else. The Directors would have to consider whether or not they should increase the rentals. Coal had gone up, and, as a consequence, gas had gone up, and he did not see why the electric light should not go up also. A 10 per cent. increase on the rentals would make all the difference between the 3½ and 5 per cent. required for the debentures. There was no doubt they were a pioneer Company, and pioneers always met with difficulties, but he firmly believed that if people could be got to take an additional number of lamps, they would become a very prosperous concern. At the present time they had to raise this £6,000 of debentures. At a previous meeting the shareholders promised to take a certain amount, and he hoped that the Directors would see their way to the remainder and so keep the concern going. If this was not done they would have to face the matter in the way of reconstruction, but as at present advised he did not think it would be necessary to adopt that course. If the whole of the debentures were subscribed for, the Directors would be in a much better position to see what should be done. There was no doubt about this, that if the whole of the machinery were running at its full power they would be doing a large business. He hoped they would see their way to carry the concern on for 12 months, and that shareholders would recognise the necessity of getting people to take the light—for the light must be had, whether this Company supplied it or not—and so doing their best for the interests of the Company. He moved the adoption of the report.

Mr. H. G. Massingham said he would second the motion. As the largest shareholder in the Company, he regretted that there was no dividend. The past year was a very abnormal one, and increased expenditure was occasioned by the running of the two depots for some time, and the delay caused by the very stringent regulations of the Board of Trade in the arrangements of the circuits. At the same time he took a more hopeful view of the position of the Company than did the Chairman. There was, in his opinion, a bright future for the Company. He remembered that in the early history of gas companies they had difficulties to meet, and it took them a longer time to get over them and become successful commercial concerns, than he considered it would electric light companies. He referred to the efficient condition of the plant, which was at present only running at one-quarter of its power, so that without any additional expenditure of plant a great extension of business might be made. Since the formation of the Company they had paid 16 per cent. in the way of dividends, or, including the present year, an average of 4 per cent. per annum.

The **Chairman** said it must not be understood that he advocated the payment of 3½ per cent. on the debentures. They were guaranteed at 5 per cent., and that would have to be paid whether it was made or not. If the profit was not paid the £100 would have to be capitalised.

The report was then adopted.

Mr. G. H. Kite moved the re-election of Mr. A. Lewis as a director. They all knew that the Directors gave up considerable time to the working of the Company, and during the past year they must have have had a great deal of anxiety. As a shareholder, and as the solicitor to the Company, he did not take a desponding view of the position of the Company—he was rather disposed to look at it in the same light as Mr. Massingham did. The Company had come to that crisis when it wanted outside help to make it a paying concern. The light had been taken up in Taunton in a manner far exceeding early anticipations, and it would be a great pity if shareholders allowed it to collapse for want of capital. The Company was possessed of one of the most complete depots outside of London, and was in perfect working order. What was wanted was that the shareholders should put their shoulders to the wheel and obtain new customers; if they did so, he believed that by this time next year the Company would be in as prosperous a condition as they could wish. The shareholders should also do their best to obtain the debenture capital, as in that way they would be enabled to earn a dividend for the ordinary shares. The original debenture issue of the Company was £3,000, which was secured on the first mortgage of the Company's works and plant. Without increasing the debenture issue they had more than doubled the security, so that there need be no fear that there was not sufficient security. The debenture holders, if the worst did happen, would be able to take the freehold premises and machinery and sell them, they could carry on the works, or form a new company, and they would have a great bargain in obtaining them for £6,000.

Mr. W. Potter seconded the motion, which was agreed to.

A motion having been carried re-electing Mr. H. G. Massingham as a director, that gentleman replied, and spoke of the probability of the holding of an electrical exhibition in Taunton during the autumn. Such a scheme could be carried out with the cooperation of the Directors and the railway company, and would do much to popularise the use of electricity. He believed in the future of electricity as an illuminant, as well as a motive power. For some time past, as they were no doubt aware, they had been supplying power for blowing the organ at St. John's Church. In course of time this branch of the business could be increased.

In moving the re-election of Mr. A. Goodman as auditor, **Mr. A. Chapman** said that he (the speaker) had prepared an estimate showing the earnings of the Company if the plant was fully worked. They had four dynamos for arc lamps, three of which were being worked. If the four were worked it would give them a revenue of £1,500 a year; they had two incandescent machines capable of lighting 1,200 lamps of 16 c.p., which would mean a rental of nearly £1,000 a year, and another dynamo working the storage battery. They could make £2,500 a year on an expenditure of but little more than £1,900, including the interest to debenture holders. This would leave about £600 to be divided amongst the ordinary shareholders.

The motion was adopted.

A vote of thanks to the Chairman terminated the meeting.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

The twenty-seventh ordinary general meeting of this Company was held on Tuesday at the offices, Old Broad-street, Sir G Elliott, M.P., presiding.

The **Chairman** said they had laid during the year 4,000 miles of submarine cable, and they had manufactured a considerably larger quantity. Part of these contracts remained unexecuted, and the work was going on in the present year, the prospects of which, he was glad to say, seemed very encouraging. They were at the present moment laying a cable from Madras across the Bay of Bengal, and loading another cable at their works for the Indian Ocean. He hoped they would continue to be satisfied with the dividend of 20 per cent., which the Directors were enabled to pay, leaving something as a nest-egg for the current year.

The motion to adopt the report and accounts was carried, as also were others re-electing the retiring Directors and Auditors.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended February 27 amounted to £5,998.

Bell's Asbestos Company.—Mr. Henry Heywood, of the firm of Heywood Brothers, of Cardiff, has joined the Board of Directors.

Eastern Extension Telegraph Company.—The receipts for February were £43,833, as against £38,466 in the corresponding month of 1890.

Eastern Telegraph Company.—The traffic receipts for the month of February were £59,155, against £53,347 in the corresponding period of 1890.

Cuba Submarine Telegraph Company.—The estimated traffic receipts for the month of February were £3,400, as compared with £3,391 in the corresponding month of last year.

West India and Panama Telegraph Company.—The estimated traffic receipts for the half-month ended February 28 were £2,445, as compared with £3,170 in the corresponding period of 1890.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 27, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,895.

The Anglo-American Telegraph Company has opened branch offices at Hay's Wharf, Tooley-street, S.E., and 46, Mark-lane, E.C., for the reception of telegrams. Offices will also shortly be opened in Edinburgh, Leith, Dundee, Bradford, and Newcastle-on-Tyne.

City and South London Railway.—The receipts for last week were £753. The receipts for the previous three weeks were as follows: February 7, £702; February 14, £702; February 21, £718. The total amount received during the month was, therefore, £2,875.

Direct Spanish Telegraph Company.—The estimated receipts for the month of February were £1,953, against £2,225 in the corresponding period of last year. The Directors recommend a dividend at the rate of 10 per cent. on the preference, and at the rate of 6 per cent. per annum, together with a bonus of 1 per cent. (both tax free), on the ordinary shares, making with the previous half-year's dividend a total distribution of 7 per cent. for the year on the ordinary shares.

National Telephone Company. — This week the Directors issued £350,000 4½ per cent. debenture stock, forming part of a total amount of new debenture stock which is limited to one half of the subscribed share capital of the Company for the time being, and redeemable at the option of the Company on six months' notice at £110. The capital of the Company is £4,000,000, of which £2,494,920 has been issued. Notice has been given to pay off the existing debenture stock and bonds. The new debenture stock will then be constituted a first charge on the entire undertaking and property of the Company.

Keswick Electric Light Company.—The first report of the Directors states that the demand for light exceeds the means of supply, and they have, therefore, added another dynamo to their plant, and are going to put up a second turbine. The profit and loss account for the 11 months ending December 31st, shows a credit balance of £34. 15s. 8d., enough to pay a small dividend, but the Directors consider this amount should be held in reserve. The total number of lamps now connected with the station is 705, including one 500-c.p. arc lamp. In response to a circular, dated 13th October last, the shareholders had taken up £1,000 worth of unissued shares, leaving £1,645 still to be disposed of. The station was started on February 1st, 1890.

PROVISIONAL PATENTS, 1891.

FEBRUARY 23.

3239. **Improvements in underground conduits for conductors of electricity**. John Smith Raworth, Thomas Octavius Callender, and Charles Edmund Webber, 46, Lincoln's-inn-fields, London.

3262. **An improvement in conductors for electrical glow lamps.** Edward Alfred Gimingham, of the Edison and Swan United Electric Light Company, Limited, 28, Southampton-buildings, London.

3269. **An improvement in or connected with mechanical telephones.** Forrest William Dunlap, 53, Chancery-lane, London.

FEBRUARY 24.

3331. **Improvements in secondary or storage batteries**. Stanley Charles Cuthbert Currie, 323, High Holborn, London. (Complete specification.)

3336. **Improvements relating to welding, brazing, or otherwise joining metal strips, bars, rods, and the like by electricity, and to apparatus therefor**. Henry Harris Lake, 45, Southampton-buildings, London. (Herman Lemp and Louis M. Schmidt, United States). (Complete specification.)

3338. **Improvements in telegraphy**. Josiah Atkins Parker, 23, Southampton-buildings, London. (Complete specification.)

3349. **Improvements in electric welding apparatus.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

3357. **Improvements relating to the jacketing of pipes and cocks, chiefly designed for use in connection with vacuum pumps for exhausting incandescent electric lamps**. Henry Harris Lake, 45, Southampton-buildings, London. (Adolph Berrenberg, United States.) (Complete specification.)

3364. **Improvements relating to the manufacture of incandescent electric lamps**. Henry Harris Lake, 45, Southampton-buildings, London. (William Emery Nickerson and Adolph Berrenberg.) (Complete specification.)

3383. **Improvements in dynamo-electric machines.** John Augustine Kingdon, 29, Marlborough-hill, London.

FEBRUARY 25.

3398. **An improved electrical burglar* alarm** Arthur Ernest Spencer, 17, Coleman-street, London.

3404. **Improvements in switches for telephone circuits**. Charles Herbert Elliott and Ernest Frank Furtado, 10, Bush-lane, Cannon-street, London.

3417. **An improved galvanic battery**. William Henry Munns, 55, Chancery-lane, London. (George A. Smith, Canada.)

3426. **Improvements in brushes and brush holders for electric machines.** Herbert John Dowsing, 4, Queen Victoria-street, London.

3449. **Improvements in telephones.** Parnell Rabbidge, 9, Southampton-buildings, London. (Complete specification.)

3450. **Improvements in primary batteries**. Willoughby Hamilton Power, 22, Southampton-buildings, London.

3455. **Improvements in electromagnetic percussive rock drills and the like.** William A'Court Granville Birkin, 166, Fleet-street, London.

FEBRUARY 26.

3495. **Non-percussive quick-break electric switch**. Charles Mark Dorman and Reginald Arthur Smith, 24, Brasenose-street, Manchester. (Complete specification.)

3524. **Improvements in apparatus for use in the manufacture of metal tubes by electro-deposition**. Richard David Sanders, 4, South-street, Finsbury, London.

FEBRUARY 27.

3538. **Improvements in electrical contact apparatus and parts connected therewith, for automatic stop motions and analogous applications in spinning, twisting, winding, and other machines or apparatus**. John Mackie, 87, Vincent-street, Glasgow.

3553. **Improvements in conduit electric railways**. William Phillips Thompson, 6, Lord-street, Liverpool. (Ernest M. Reed, United States.)

3570. **Improvements in electro-therapeutic apparatus.** Frederick George, 11, Talbot-street, Southport.

3589. **Improvements in electric batteries**. Henry Harris Lake, 45, Southampton-buildings, London. (William B. H. Dowse, United States.) (Complete specification.)

3592. **Improvements in electric alarm apparatus.** Walter Whitehead, 33, Chancery-lane, London.

3609. **Improvements in electricity meters**. Eugen Hartmann and Wunibald Braun, 47, Lincoln's-inn-fields, London. (Complete specification).

FEBRUARY 28.

3628. **Improvements in dynamometers or force measurers.** George Richard Postlethwaite, 124, Park-road, Aston, near Birmingham.

3629. **Improvement of insulators**. Charles Dexter Barker, 76, Turnmill-street, London.

3643. **Improvements in means for holding portable electric lamps**. Frederick John Rowan and William McWhirter, 87, St. Vincent-street, Glasgow.

3650. **Improvements in electric clocks**. Leon Pope, 10, Stonefield-terrace, Barnsbury, London. (Complete specification.)

3664. **Improvements in electrical switches**. Gustav Binswanger, 71, Queen Victoria-street, London.

3673. **Improvements in electric arc lamps**. Albert Cooper Seibold, 28, Southampton-buildings, London. (Complete specification)

3675. **Improvements in apparatus for the transmission of telegraphic messages by means of direct or alternate electrical currents**. Edmund Edwards, 35, Southampton-buildings, London. (Complete specification.)

3680. **Improvements in electric lighting apparatus for gas burners**. Henry Harris Lake, 45, Southampton-buildings, London. (The Aktiebolaget Gôranssons Mekamska Verkstad Company, Limited, Sweden.)

SPECIFICATIONS PUBLISHED.

1890.

180. **Automatic telegraphs**. Edwards. (Cassalette and another). 1s. 1d.

1939. **Electric temperature alarm**. Bougault. 8d.

2219. **Telegraph printing apparatus**. Rudolph. 11d.

2273. **Voltaic cells**. Postlethwaite. 11d.

2297. **Electrolytic apparatus**. Richardson and Holland. 8d.

2298. **Electric calls, etc.** Gardiner. 8d.

2337. **Electromagnetic motors**. Postlethwaite. 8d.

4242. **Electric railway signals.** Siemens. 8d.

4384. **Secondary batteries**. Pitkin and Holden. 6d.

4699. **Telephony**. Kellogg. 11d.

4767. **Electromotors and dynamos**. Sherrin. 8d.

4858. **Dynamo-electric machines**. Kapp. 8d.

14197. **Electric motors.** Lake. (The Thomson-Houston International Electric Company.) 11d.

17560. **Electric switches.** Illiffe and Barton. 8d.

18409 **Electrical switches, etc**. Davies. 6d.

18993. **Electric clocks.** Prokhoroff and Fahlberg. 8d.

20099. **Telephone exchange apparatus.** Kinsbury (Western Electric Company). 8d.

20134. **Suspending electric light, etc., cables.** Fawcus and Cowan. 6d.

20289. **Insulating compositions.** Bottome. 4d.

20307 **Electrical switches.** Dahlgren and Svensson. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2¼
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2¼
Swan United	3½	4¾
St. James'	—	6
National Telephone	5	4¾
Electric Construction	10	7¼

NOTES.

Telephone Clerks.—Only female operators will be employed in the Berlin telephone exchanges henceforth.

Richmond.—The Richmond Corporation appointed an Electric Lighting Committee at their last Council meeting.

Hawaii Cable.—The U.S. Navy Department is making arrangements for a survey for the proposed cable between San Francisco and Hawaii.

Dry Cell.—A new form of dry cells made by Messrs. Dalle, Molle, and Co., of Ancona, is stated to be very successful in arsenal at the Spezzia.

Lynton.—At the last meeting of the Lynton Local Board the surveyor reported that the electric lighting works had been repaired and the light was now good.

Bristol.—The Bristol Town Council, on Tuesday, resolved to expend £66,000 in establishing electric lighting in the city. The matter is fully alluded to elsewhere.

Scholarship.—The Clothworkers announce an exhibition scholarship of 50 guineas, for encouragement of proficiency in physical science, at Cambridge for July next.

Ipswich.—The alterations in the Ipswich provisional order, to omit several streets in the compulsory area, asked for by Messr. Laurence and Scott, have been refused.

Electric Traction in Austria.—The latest project is for an electric line in Austria, between Herculesbad and a station on the Vienna-Orsova Railway in the neighbourhood.

Concert.—A very high-class programme was before the Old Students last Saturday, in which stringed instruments played a prominent part. The concert was thoroughly enjoyed.

Deptford.—An interesting and important report upon the Deptford and Grosvenor stations, by Mr. Ferranti, will be found embodied in another column, under "Companies Reports."

Lifts in Madrid.—Lifts are coming into fashion at Madrid, and several hundreds will be required during the course of the year. As electricity is also in favour, the combination might also be adopted.

Paris Lighting.—The concession for lighting one of the Paris sections has been secured by Messrs. Woodhouse and Rawson, and we believe a company will be formed at once to carry out the central station.

O.S.A. Dance.—A Cinderella dance will be held by the Old Students at Westminster Town Hall on Friday, April 10th; tickets (3s. 6d. each) can be had of the secretary, 88, Queen Victoria-street.

Electric Burgling.—The latest dodge of burglars is to use the electric furnace—that is, carbon points—to soften the steel of safes. Those banks that are fitted with electric light, therefore furnish the means on the spot.

Buckingham Palace.—Even if the fog had interfered at the last Drawing Room, light would have been plenteous, for the Westminster Electric Supply Company connected their mains to the Palace on the day before the State ceremony.

Underground Telephones.—An application from the National Telephone Company to the Commissioners of Sewers to allow the laying of cables beneath the public ways in the City was laid before the last meeting and adjourned.

Franco-Belgian Telephone.—The French Director of Posts and Telegraphs states that all the telephone exchanges in the North of France (Lille, Roubaix, and Tourcoing) will be connected to the Belgian exchanges, and that a third wire is to be run between Paris and Brussels.

Electric Traction at Lyons.—In a recent sitting of the municipal authorities of Lyons, it was decided to grant a concession to the Compagnie Lyonnaise des Tramways et Chemins de Fer for a line of electric tramway running from the Gare des Dombes to the Gare de Perrache.

Leamington.—An enquiry was held on Tuesday at Leamington, by Major Marindin, inspector of the Board of Trade, respecting the applications of the Midland Electric Light Company and the Leamington Corporation for provisional orders. Evidence was taken, and the enquiry adjourned.

Acme Works Branch.—The West-end branch of the business of the Acme Electric Works has been purchased by Messrs. C. Moat and Co., and for the future it will be carried on under that title, and all the "Acme" specialities may still be obtained, together with the goods of other makers.

African Cables.—The Spanish Government is going to lay the cable at its own expense from Bonny, on the African continent, to Fernando Po, and the German Government thence to Cameroon. The Eastern Telegraph Company has sent its cable ship "Amber" to the Cameroon waters to take bearings.

Papers.—The following papers have been arranged to be read before meetings of the Old Students' Association: "Coal, Coal Mines, and Coal Mining," bv Mr. Albion T. Snell, on March 25; "Explosives," by Mr. W. M. Heller, on April 29; "Some Experiments in Magnetism," by Mr. Ernest B. Vignoles.

Chesham House, which is the finest of the ambassadorial mansions in London, is now being fitted up with the electric light, and the introduction of the new illuminant will enhance the effect of the splendid apartments of the Russian Embassy when the customary receptions take place during the season.

Ballymena.—Tenders are required for lighting Ballymena, Ireland, with gas or electricity, from August 16th, 1891, until May 16th, 1892, for the Town Commissioners. The table of lighting and other information are to be had from Mr. Henry O'Hara, Ballymena, to whom sealed tenders are to be sent by 16th inst.

Perls' Electric Signalling.—A system of electric railway signalling between engine and station is described in the *Times*, of which a working model has been on view at 62, Basinghall-street. Ten Leclanché cells are carried on each engine, and call-bells can be rung through auxiliary rails to and from the stations or signal-boxes.

City Offices.—Mr. Wilson Hartnell, M.I.M.E., is opening offices in London about the end of this month at Mansion House-chambers, 11, Queen Victoria-street, E.C., under the management of Mr. Farrar. In addition to electric lighting and power plant, he will continue the manufacture of general engineering as heretofore.

Board of Trade Unit.—The desire is apparent in Mr. Preece for a name to indicate the Board of Trade unit, and at one time he ventured on the term "bot"—a mongrel since abandoned. We have the term kilowatt for 1,000 watts, why not simply "kilowatt-hour" for 1,000 watt-hours—the Board of Trade unit, if a term is necessary.

Patent Office.—The questions recently put in the House of Commons relative to the Patent Office fees have evoked so many letters from inventors urging Mr. Leng to take up the question, that he has resolved to bring it before the House on the estimates for the Board of Trade, which has the superintendence of the Patent Office.

City Lighting.—The Streets Committee of the Commissioners of Sewers have received a letter from the Board of Trade signifying, with reference to the lighting of the City, that they were satisfied that the undertakers were in a position to discharge the duties and obligations imposed upon them by the order. This was agreed to without discussion.

Stafford.—A meeting of the Stafford Town Council was held on Tuesday. The Electric Lighting Committee reported that out of 154 circulars sent out only 27 replies had been received, and of these only two persons proposed to adopt the electric light. The committee, therefore, did not feel justified in recommending the expense of an installation at present.

Electric Flash Light Photography.—Mr. Adamson, of Glasgow, a well-known photographer, has succeeded, we hear, in obtaining excellent instantaneous group photographs by employing a series of incandescent lamps instantaneously flashed much over-incandesced. The distributed white light which results has rendered ballroom and other similar subjects very successful in a photograph.

Partnership.—Messrs. Barnett, Barnard, and Co. have taken into partnership Mr. W. R. Wynne, who has recently held responsible positions under the Westinghouse Electric Company, and the India Rubber, Gutta Percha, and Telegraph Works Company, of Silvertown. The style of the new firm will be Messrs. Barnett, Wynne, and Barnard, and their address, 92, Quayside, Newcastle-on-Tyne, as before.

St. Pancras Electrical Exhibition.—At the forthcoming electrical exhibition at the Vestry Hall, St. Pancras, the General Electric Power and Traction Company will have a very interesting show of motors driving domestic and other machinery, such as knife cleaners, washing machines, etc., as well as electric light fittings, switches, and lamps. The exhibition opens on Monday next, the 16th inst.

Telephoning to Trains.—To enable the guard of a train to give notice of breakdown from any point on the line, M. Maubogne effects communication, says the *Engineer*, between one or more of the telegraph wires and a micro-telephonic apparatus, to be carried by every train by means of a conductor terminating in a hook, to be rubbed hard against the wire to secure contact in spite of oxidation.

Garrick Theatre.—Messrs. Rashleigh, Phipps, and Dawson, electrical engineers to the Garrick Theatre, point out that the accident on the first night of the play was caused by the limelight man having been placed close to the resistances, and by his movements interfering with the proper working of the apparatus. The lighting of this theatre has been worked without a hitch of any kind for two years.

Electrical Production of Aluminium. — M. Adolphe Minet, having previously described the method of producing aluminium electrically, mentions in a note given this week in the *Moniteur Industriel*, that in the modified electrolytic process now adopted he attains the production of 32 grammes of aluminium for one horse-power hour. He uses an E.M.F. of only four volts, and the return of electric energy is given as 70 per cent.

Lea Bridge Tramways.—At the half-yearly meeting of the Lea Bridge, Leyton, and Walthamstow Tramway Company, the chairman stated that owing to the possibility of electricity or some other form of mechanical traction coming into use, the directors had not deemed it necessary to acquire a large number of horses, but had entered into an agreement with a large contractor for the supply. The line itself in many parts was in an incomplete state.

South Kensington Railway.—The London County Council are retaining Sir Benjamin Baker as witness in support of the Council's opposition to the South Kensington and Paddington Subway Bill. It is understood that, owing to the opposition from the Science and Art Department, the idea of driving the cars by electricity will be abandoned. The proposal is now to have a solid concrete cable tramway about 4ft. under the level of the Kensington Park Gardens, with or without a station in the gardens.

"The Phonogram."—We have received a copy of the first number of a monthly magazine under the above title, published at the World Building, New York, which mixes up items about the phonograph and electricity in a way that is calculated to still further foster the idea that Edison's invention is electrical. As the phonograph increases in usefulness it will no doubt require a magazine, but a musical, linguistic, reporting, and clockwork invention should not be floated in on electrical pretensions.

The British Association.—The following have been appointed to preside over the sections at the Cardiff meeting of the British Association in August next: (A) Mathematics and Physics, Prof. O. J. Lodge, F.R.S.; (B) Chemistry, Prof. Roberts-Austen, C.B., F.R.S.; (C) Geology, Prof. Rupert Jones, F.R.S.; (D) Biology, Mr. Francis Darwin, F.R.S.; (E) Geography, Mr. E. G. Ravenstein, F.R.G.S.; (F) Economics, Rev. Dr. W. Cunningham; (G) Mechanical Science, Mr. T. Forster Brown, M.I.CE.; (H) Anthropology, Prof. Max Müller.

City Subway.—In the House of Commons on Friday last, Mr. T. H. Bolton moved that clauses be inserted in the City and South London Railway Bill providing either for payment of royalty or share of earnings to the local authority, or for specially reduced fares on a specified number of workmen trains for workmen and clerks. Sir John Puleston said he was authorised by the promoters to state they were prepared to deal with the second question. The instruction to the committee was, as a whole, negatived, and similarly with the other proposed subways.

Electric Lighting in Wales.—Margam Castle, near Port Talbot, the property of Miss Talbot, is to be lighted throughout with the electric light. The contract for the work has been placed with Messrs. Drake and Gorham, whose proposal amongst several submitted for consideration was accepted. The installation will consist of a large turbine, which will suffice for the ordinary lighting requirements, and a steam engine is also to be provided for use at such times as the water power is not available. Mr. A. A. Campbell Swinton will act as consulting engineer on behalf of Miss Talbot.

Telephone Instructions.—The following striking "poem" was composed by one of the Western Counties and South Wales Telephone Company's Bristol subscribers, and placed on his telephone for general information:

"Speak softly through the telephone,
Just modulate your tongue,
A soft clear voice is better far
Than Stentor's brazen lung."

"Don't hollah through the telephone,
And rage, and shriek, and roar,
You'll hurt yourself and do no good;
Oblige by speaking lower."

Moral (!) Electricity.—A contemporary whose efforts and funds are usually supposed to be zealously devoted to the cable telegraph interests, delivered itself of a leaderette upon, of all subjects, Wesley—probably because the daily press were discoursing upon his centenary; and in the course of remarks therein, laid to the charge of the enthusiastic divine a claim for the cure of "moral" diseases by electricity, quoting as follows: "*Felons* are specially cured by drawing sparks." We wonder if our sapient contemporary ever heard of the old term for a carbuncle or whitlow as a "felon." The ascription to the good John Wesley of the cure of felony ("moral diseases") by drawing sparks is surely a little too green.

Barnet.—The Barnet Local Board at their meeting last week, discussed at great length the question of the means to be adopted for lighting the town after the expiration of the present electric lighting contract, which holds good up to the end of August. Ultimately they decided to continue the use of electricity for illuminating purposes.—At the half-yearly meeting of the Barnet Gas and Water Company, Mr. Wakefield, a shareholder, suggested that as electricity gave promise of being the lighting agent of the future, the directors might try experiments in that direction. The chairman said he could not allow risk to the shareholders; as soon as their company could pay statutory dividends they might experiment with confidence.

Personal.—Messrs. Leslie Miller and Maurice W. Woods have commenced business together as electrical engineers and contractors at 34, Gray's-inn-road, Holborn. Mr. Miller is the inventor of the Miller ammeter and voltmeter. He has been for the last 3½ years in charge of the dynamo-testing department of the Maschinenfabrik Oerlikon, near Zurich, and has also installed many of the more important electrical power transmission plants for the company. Mr. Woods has been for the last 1½ years with the Liverpool Electric Supply Company. He is one of the joint authors with Prof. Ayrton of a paper on accumulators read before the Institution of Electrical Engineers at Edinburgh, and the winner of the silver medal at South Kensington Technological Examination.

Cataphoric Medication.—A paper was read on Wednesday evening by Messrs. H. Newman Lawrence and A. Harries, M.D., on "Electricity in Relation to the Human Body." The comparative dangers to human life of continuous and alternating currents were dealt with and experiments described. The most interesting part of the paper, however, was that on the uses of electricity, during which Dr. Harries submitted a patient to the process known as "cataphoric medication," in which the drug cocaine was mechanically driven into the skin of the arm by 20 minutes' electrification by continuous current, and a needle was passed through the skin several times and hairs removed without the slightest pain being felt by the patient. Mr. W. H. Preece, F.R.S., was in the chair, and congratulated the authors.

Sensitive Galvanometer.—At the meeting of the Royal Scottish Society of Arts last week, at Edinburgh, Lord Kingsburgh, president, in the chair, Dr. R. Milne Murray described and exhibited a reflecting galvanometer for physiological work. The instrument was an astatic galvanometer of the Thomson type, with special modifications. One of these was that the mirror was placed between the two systems of needles instead of being attached to the upper system; but the principal modification was the mode of damping adopted so as to secure aperiodicity. The filament which carried the needles and the mirror had attached to its lower end a light vane, spade-shaped, which just dipped into an adjustable cup of oil, so that when the needles were deflected the capillary attraction of the oil from the vane brought the system readily to a standstill. Dr. Murray claimed for his galvanometer great sensitivity, a high figure of merit, and a remarkable degree of aperiodicity.

Bradford Tramways.—The Bradford Town Council at their meeting on Tuesday had before them the minutes of the Tramway Committee, from which it appeared that the question of steam *versus* electricity in the working of the proposed new tramway in Wakefield-road had been considered, and the committee had decided that the best motive power for the line would be electric traction on the underground system. Mr. T. C Hope (chairman of the committee), replying to questions, said that the committee had not yet ascertained the exact cost of the electric tramway. They had an approximate estimate, but were endeavouring to get the actual cost before doing anything further. The question would then arise whether anyone could be found to undertake the working of the line at the price which the committee might fix.

Concentric House Wiring.—Something very fresh and daring in the way of house wiring has been brought forward this week, and by a fire insurance official, too, we believe. This is nothing less than the bold use of bare conductors in such a manner as to do away entirely with chance of fire. Imagine one small tube of bare copper inside another, kept apart by little rings of porcelain, and there you have the very latest idea. It is maintained that if all connections are thus visible, by no chance could they be set fire to, and bare copper concentric conductors could be run in shop windows as rails for lace and trimmings with no more danger than a gas-pipe. This is something like, and the idea, once we get over our feeling of breathlessness at the suggestion, has its practical points. The inventor, it is said, is offering fifty pounds for anyone who can prove how a fire could occur or can make one with this arrangement. The rods would be tinned and screwed beforehand, and all the "wiring"—"tubing," rather—required would be to screw them together.

Kessler Magnetic Separator. — The mines of Mercadal, Spain, yield zinc ore (calamine) mixed with oxide of iron. The latter is separated by means of the Kessler electromagnetic separator. The apparatus is formed of a soft iron cylinder wound with copper wire, energised by current from a dynamo. Upon this cylinder revolve two endless chains. They are by strips of leather connected together by parallel pieces of soft iron, furnished with numerous projecting points. A bronze rail guides the ore to the chain before magnetic contact. The magnetic particles of the ore become attached to the magnetic points of the chain, and are drawn away until outside the magnetic influence of the cylinder. They then fall off into a separate compartment. A brush detaches those particles that cling more closely. The speed of rotation can be varied according to richness of the ore, and 3½ tons an hour can be treated with the employment of ¼ h.p. only. The current, 20 amperes and 20 volts, requires 2 h.p., therefore 2¼ h.p. is required for the whole apparatus. The cost of the Kessler separator is given as £90.

Central London Railway.—A long enquiry has been held this week before the Select Committee of the House of Commons, to consider the Bill for the Central London Electric Subway. The chief arrangements made are that workmen's trains should be run each way, morning and evening, at 1d. a journey, and that placards should not be displayed outside the Oxford-street stations. Sir Benjamin Baker, in the course of his examination, said that the railway was arranged to run at such a depth underground as not to interfere with the sewers, and would be constructed right through the heart of London in such a way as not to cause injury or damage to the surrounding buildings. They would require one electric horse-power to each ton weight of train; they would require 18 trains on the line to work a three-minutes' service. The trains would consist of six cars, each capable of seating 56 passengers, and on an emergency they would be able to carry 350,000 persons a day. Dr. Hopkinson, who followed, stated that he calculated the cost of the boilers, steam engines, generating dynamos, conductors in the tunnel at different places, and the locomotives necessary for hauling the trains, at £335,000.

Gordon Closed Conduit Tramways.—The interesting system of electric cars, with closed conduits, devised by Mr. J. Gordon, late German manager of the Swan Company, has been tested practically, and gives excellent preliminary results. The general idea of the system is a series of contacts, charged by means of automatic magnets in a box placed in the ground every hundred yards or so—about 16 to a mile. The preliminary trials have been made in all sorts of weather, and with very severe tests, such as flooding the whole track, 70 yards in length, with water, carting on barrow loads of earth, working in snow, fog, and so forth, through the late winter. The working pressure is 250 volts and the current about 30 amperes. The current taken in energising the magnets is ¼ ampere, and the greatest loss in running across the charged sections about one ampere—that is, in all, including resistance, say, 4 per cent. of that used. The special system ends at the contacts; any gearing or motor can be used. At present, an Immisch motor is employed with ordinary spur gearing. The system, which we have alluded to several times, now seems to be worked out in a simple and practical manner, and the tests that have been made have created a great interest in certain quarters, as showing that a practical and absolutely solid conductor rail system is applicable to street tramways. Full-sized cars are now to be built.

County Council Telephones.—The Main Drainage Committee of the London County Council report that they have had under consideration for some time past the advisability of connecting the various pumping and outfall stations and the offices of the Council at Spring-gardens by means of telephonic communication, and as they are satisfied that it would effect a large saving in time on the part of the staff, lessen labour, and be conducive to certainty and efficiency of working, they have obtained a detailed estimate from the authorities of the General Post Office and terms per annum for such telephonic communication, which estimates are as follows:

Spring-gardens to Abbey Mills, with two Gower-Bell telephones	£65	10	0
Extension from Abbey Mills to Barking outfall, with one Gower-Bell telephone and one switch	34	0	0
Extension from Abbey Mills to Isle of Dogs, with one Gower-Bell telephone	52	15	0
Spring-gardens to Grosvenor-road, Chelsea, with one Gower-Bell telephone and one switch...	31	15	0
Spring-gardens to Deptford, with one Gower-Bell telephone	62	10	0
Deptford to Crossness outfall, with one Gower-Bell telephone and one switch	72	5	0

They recommend that, subject to estimates to be submitted to the Council by the Finance Committee as required by the statute, the several lines be laid down, and be leased for seven years under the usual form of agreement.

Purchase of Railways.—The London County Council have desired to insert in the Bill for the Central London Railway a clause to provide for the ultimate purchase of the undertaking by the local authority. Mr. Pope, who, with Mr. Erskine Pollock, appeared in support of the petition, in submitting the Council's case to the committee, pointed out that the undertaking was essentially local in its character, and that from the great depth beneath the surface of the proposed line, and its class as an electric railway, with stations of a peculiar type, it was impossible that it could ever be connected with any general system of communication outside the metropolis. He pointed out that it was, in fact, a local metropolitan underground street, and never could form part of a general system; that the promoters had selected and laid down its course under land uncovered with houses and maintained open as a street at the public expense, in order to save the cost of acquiring its site; whereas, if they had designed the line to pass under houses, they would doubtless have to pay compensation to the owners and occupiers, and counsel therefore urged that this, like all similar undertakings, such as tramways and electric lighting schemes, should ultimately fall under local control, and that as railways are subject, under the Act of 1844, to purchase by the State, so this and similar undertakings, being essentially and necessarily local in their character, should be subject to regulation, and ultimately to purchase, by the local authorities. The Select Committee, however, refused to entertain the question of purchase. The clauses of the Bill are now under consideration, and the course taken with regard to them will form the subject of a future report by the Committee of the London County Council. The clause, however, which enabled the promoters to take the subsoil without compensation has been crossed out.

North Metropolitan Tramways.—The Select Committee of the House of Commons, presided over by Mr. Hanbury, evidently consider the Bill promoted by the North Metropolitan Tramways Company for the use of electricity as a motive power on lines from Clapton to Moorgate-street, and from Leytonstone to Stratford, to be an attempt, on the part of the tramway company, to override the local authorities. The application was curtly refused. The London County Council, it will be remembered, had consented to grant a license for seven years, on condition that guarantees were given for the safety of passengers and regulation of general traffic. The West Ham Corporation also assented, but sought to impose a condition that the company should agree that at any time they would, on 24 hours' notice, remove their engines and electrical plant. Mr. Pope, for the promoters of the Bill, contended that no man in his senses would contribute to the scheme if subject to such notice. Evidence for the promoters was given by Major-General Hutchinson, of the Board of Trade, who said they had electrical experts to guide them in these matters; and by Mr. Godfrey, solicitor to the company, who in cross-examination admitted that a former experiment with electric tramways, made some years ago, was a failure. The Board of Trade could at any time stop the trams in the interests of public safety. The chairman said that was all the Corporation of West Ham asked for. Mr. Adamson, general manager of the company, stated that they had 41 miles of streets, and in 1890 they carried 70,000,000 passengers. Between five and six years was the life of a tramway horse. The electrical batteries were quite isolated against coming into contact with passengers. This concluded the promoters' case, but without calling on the other side the committee decided that the preamble was not proved. The North Metropolitan will therefore either have to try electricity on other lines, or take the risk of the 24 hours' notice, or wait a year and carry the case to the Lords. The decision is a great disappointment to both tramway and electrical engineers.

Paris-London Telephone.—The most interesting electrical event that is before the public this week is undoubtedly the laying of the Paris-London telephone. For one person to be able to speak to another from London to Paris, across the sea and overland, seems nothing less than a dream of the Arabian nights, yet nothing less is expected, and, if successful, will lead to great extension of the present means of electrical communication to all parts. A most untoward happening in this connection has been the "blizzard," which so suddenly overwhelmed the country with snow and sleet this week. The "Monarch," with the telephone cable aboard, after waiting nearly a week to begin, made fast the shore end at Calais on Monday, and began paying out the telephone cable in beautiful weather on almost calm sea, when, half way across, on Tuesday the wind suddenly chopped round and blew a perfect gale from the N.W., sleet began to fall, and a furious snowstorm was soon raging. The "Monarch" had the greatest difficulty in proceeding, but struggled through and laid the cable to St. Margaret's Bay, near Dover, but was quite unable to land the shore end. The cable was therefore buoyed, and the captain of the "Monarch" was glad enough to take refuge at Deal. The land line on both sides is complete: that to Dover is taken on a new set of posts carrying double cables, a complete metallic circuit, two wires to the cable crossed continually to obviate induction; and Mr. Preece informs us that the speaking on the land line is perfect, better than any London circuit, and as good as from one room to another in the Post Office. There are 80 miles of land line to Dover, and 180 from Paris to Sandgate, where the French shore end lands. The cable itself has four thick copper wires, two of which will be used at first and the other two, if found necessary, afterwards. The total cost is estimated as about £80,000. At first four call boxes will be connected, and the respective Governments look to Stock Exchange interest to recoup them for their trouble. A West-end branch will be opened in London, and means will be taken to enable private wires to be connected. The price will be 8s., or 10f., for two minutes' conversation, with the proviso that each applicant follows his order, and no amount of money will enable one man to hold the line if another wishes to follow. The line can be used for telegraphic purposes in the night-time if not otherwise required.

Godalming.—The Godalming Town Council have adopted a scheme of electric lighting, which is estimated to cost £7,000 for plant, building, and site. The estimated working expenses are £900 per annum, and the revenue £1,250, leaving a balance of profit of £350. The co-operation of Charterhouse has been solicited, but the authorities do not feel in a position to join at present. The Council, therefore, have considered the scheme for town lighting only, the main features of which are as follows: The central station plant to consist of two boilers, 52 h.p. each, two 65-h.p. engines, two arc light dynamos, three incandescent ditto, and all switches and sundries. The cable mains to be laid in subways, the street lamps to be 35 arcs of 300 c.p. each. Provision for private lights to be 800 incandescent lamps of 16 c.p. Careful estimates of the above have been obtained amounting to £5,565. A site has been offered for the central station which the engineers report on as being most favourably situate for the purpose, especially if the lighting is extended at any future time to the outside district. One or two other sites are obtainable. It is approximately estimated the site and necessary buildings would cost from £1,200 to £1,500, making the total outlay for plant, site, and buildings nearly £7,000. The working expenses have been carefully estimated as follows: Coal, £170; labour, £200; carbons and sundry, £100; depreciation, £140; 4 per cent. on capital, £280; total, £890. The yearly revenue: £280 present cost of borough lighting; £962. 10s., say 700 lamps taken up at average cost of 27s. 6d.; total, £1,242. 10s. The balance of profit shown by this statement amounts to £352. 10s. per annum. This return is based on the condition of 700 lights being taken up at an average price of 27s. 6d. This price of 27s. 6d. per lamp is stated as about equal to half the cost of a gas burner using 7ft. per hour, and burning the same length of time. It is probable that the plant proposed would supply actually 1,000 lights if required. The committee are advised that the scheme is as perfect as it can be made, that all the machinery is duplicated to avoid the possibility of breaking down, and that the whole would be of the very best manufacture. The central station would also be so arranged as to admit of easy further extensions from time to time. The town clerk was instructed to send the report to the Local Government Board, and request them to hold an enquiry.

Repairs of Incandescent Lamps.—The cost of maintenance of electric installations is materially enhanced by the breakage of incandescent lamps before their time, and attempts have been made to render the repair of broken filaments a practical trade. How far this will become general or profitable will depend upon the cost price at which the glow lamps are retailed as compared with the cost of repairing, but at the present price used up globes should repay repair, and we believe that in this country Messrs. Shippey carried on a somewhat extensive trade in this direction. We see that the process of repairing lamps quickly and economically adopted and developed by a French engineer, who has for several years devoted considerable time to this problem, is described in the French technical journals as a really practical method. The lamp after being repaired is reconstituted without change of form, and the life of the repaired lamp is at least equal to the original. The process gone through is as follows: The glass-blower takes the lamp and makes at the top a hole large enough to admit a new filament. The lamp thus opened is passed to a girl, who, by means of special nippers, cuts the broken filament, which she removes, being careful to leave on each platinum support about one millimetre of filament. A second girl takes the prepared lamp and places it in a socket to which current is led; she then fills the bulb with a hydro-carbon liquid, and introduces a new filament previously standardised. By the aid of a pair of special pliers she touches the filament to one of the ends left and turns on the current. The liquid becomes decomposed into hydrogen, which rises through the liquid, and into solid carbon, which is deposited upon the joint, firmly connecting the filaments together. The same is then done for the other end of the new filament. The next process is the cleaning of the glass bulb, which, it is stated, becomes, if anything, cleaner than the new lamps. The glass-blower then takes the lamp again, attaches a tube of glass to the opening made, and the repaired lamp is then exhausted, the process of exhaustion taking three-quarters of an hour, each pump carrying five lamps. The bulb is then closed in the usual manner. The different operations described are performed very rapidly, and form an elegant and practical process, and may be repeated many times. For "Sunbeam" lamps the process is easier still on account of the size, and may be performed either to replace filaments or to clean the bulb. The best proof, says *L'Electricien*, that the process of M. Pauthonnier is really commercially practical is that it is to be introduced on an extensive scale into the United States at once.

UNDERGROUND MAINS.—V.

THE BROOKS SYSTEM.

(Continued from page 242.)

Messrs. Johnson and Phillips have made several very severe tests of the system at their works, and continue to have the strongest convictions that it is a reliable and efficient one. A line of 700ft. in length was laid down at Charlton, under the supervision of Mr. David Brooks, who visited this country in order to convey to Messrs. Johnson and Phillips his past experiences in the carrying out of his method. The cable consisted of seven No. 18 wires, each wire double cotton-covered, and braided with cotton twisted into a cable and braided over all; this length of cable was drawn into a 1in. iron pipe, and the whole system filled with hot fluid dielectric. The line has now been *down for about two years*, and it is to-day as perfect *as when first completed. During the interval* many searching tests of the line have been made, and on many occasions six of the wires have been grouped into two circuits of three wires each, and a Kapp alternator giving 2,000 volts has been connected to one end of the line, and a group of incandescent lamps lighted at the other end for several hours continuously. Measurements made before and after the run showed no fall in the insulation, and it must be remembered that in this case a pressure of 2,000 volts was exerted between wires whose covering of cotton did not exceed $\frac{1}{16}$in., intimately twisted together. Some details of the tests made at the time upon this line were given in our issue of September 20, 1889.

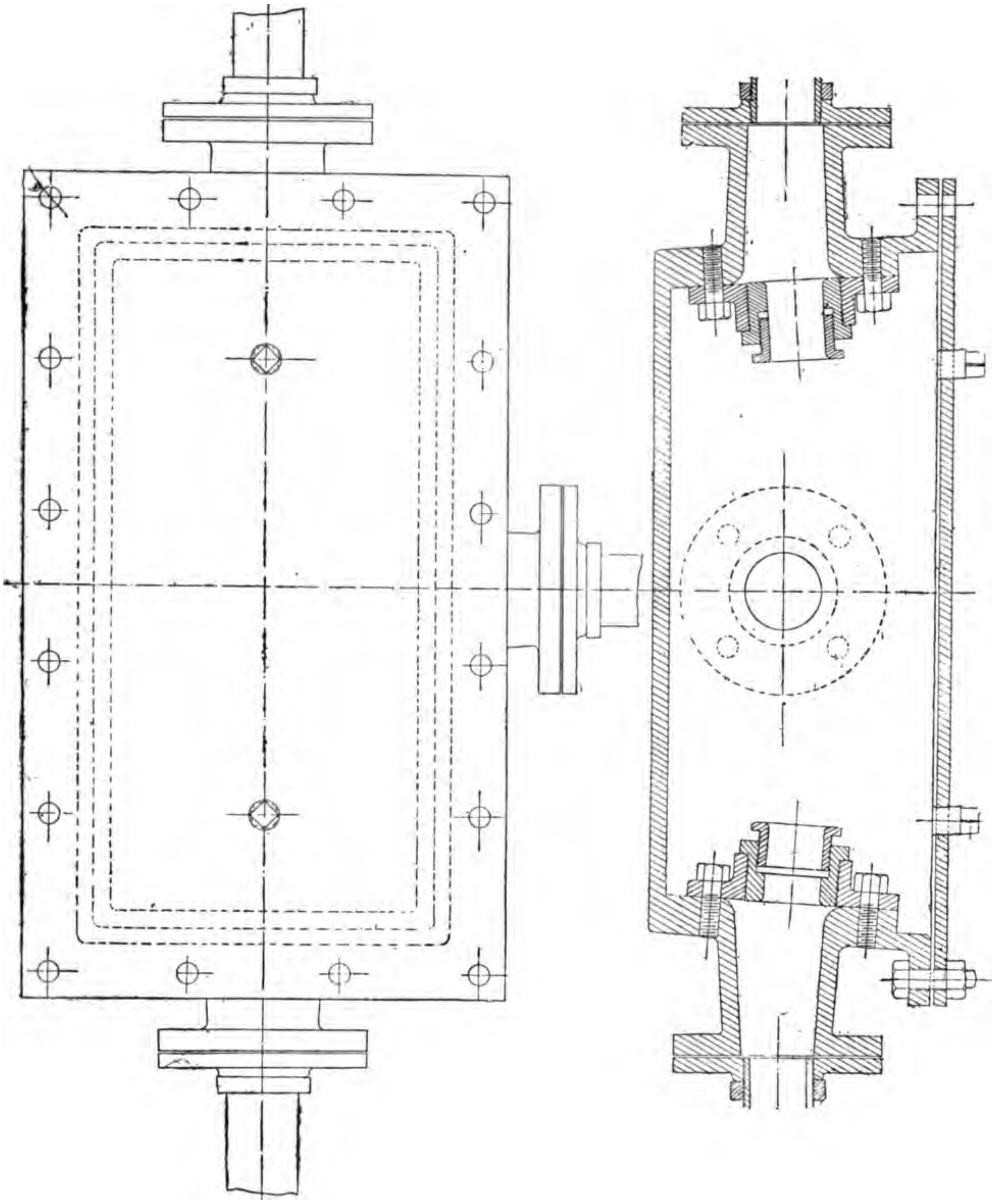


Fig. 7.—Junction Box, Brooks' System. Plan and Section.

Another line was afterwards put down at Charlton, one-tenth of a mile in length, containing two cables, each of $^7/_{14}$ wires, braided with a fibre to a diameter of about $\frac{5}{8}$in. These were drawn into the pipe in two lengths, and the whole system filled with dielectric. This line has frequently had, under the direction of Mr. Kapp, a pressure of 14,000 volts for five hours at a time upon it. The test was made by transforming up from a 2,000-volt Kapp alternator to 14,000 volts, and at the other end transforming down again to 2,000 volts, and then lighting 20 100-volt incandescent lamps in series to full brightness. This potential gave a sparking distance between points of $\frac{13}{16}$in. at the dynamo end of the line, and at the far end a somewhat greater distance. The line tested immediately before and after the run showed no change in the insulation value.

A recent communication from America dealing with this system gives particulars of underground mains with liquid insulation laid for the Heisler Electric Company, which gives entire satisfaction, having been in constant use for nearly a year in circuits using very high E.M.F., varying from 2,400 volts up to 4,000 volts, and the remarkable feature is the fact that the insulation resistance is higher to-day that when first installed. Repeated efforts have been made to break down the insulation by subjecting it to various and unusual strains, such as suddenly breaking the circuit when the dynamo was running at its greatest speed, and also subjecting lengths of the line to a static charge equal to 140,000 volts. They stood perfectly, though this test is sufficient to break through every other kind of insulation, however perfect it may appear by galvanometrical tests.

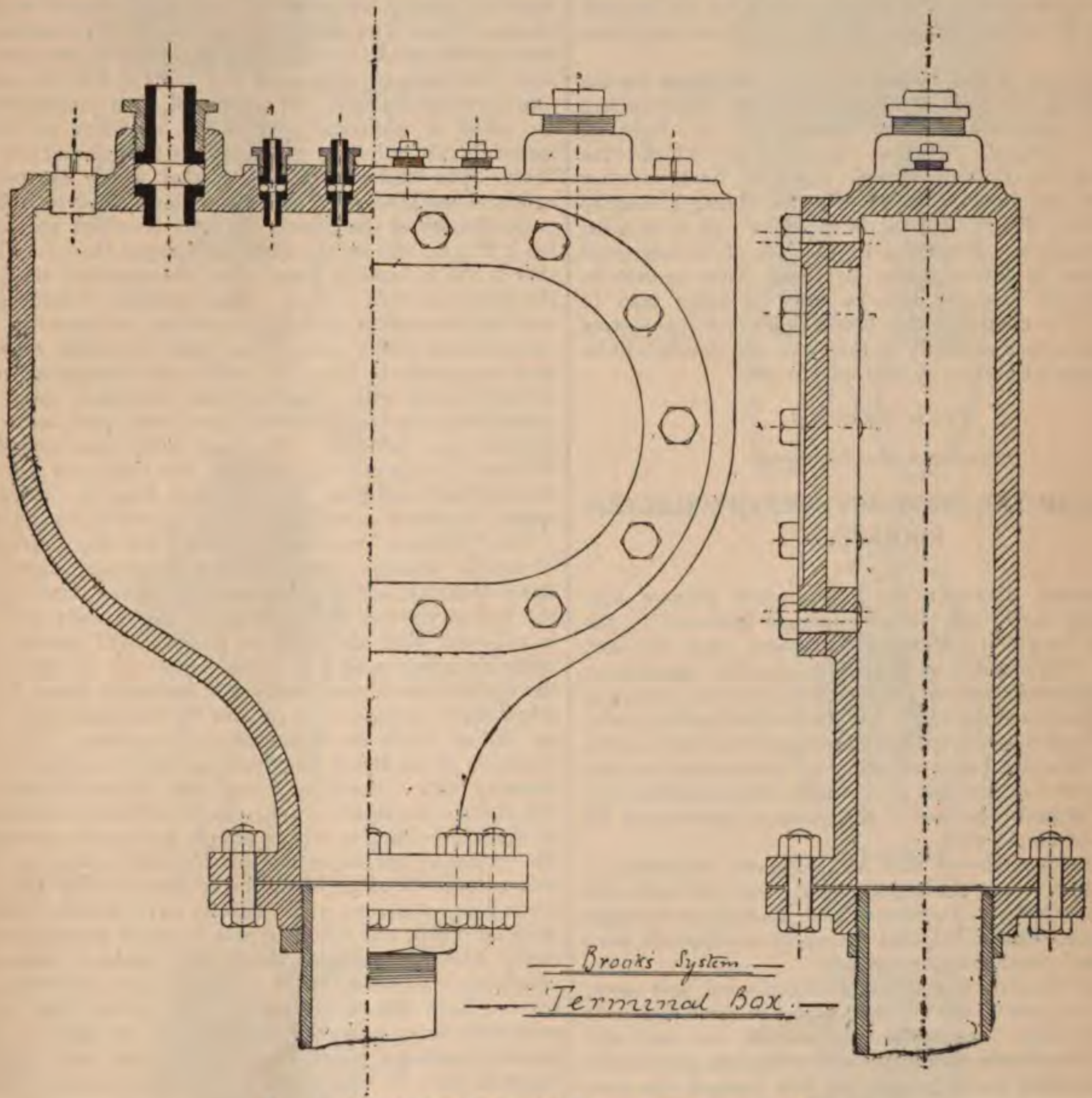


Fig. 8.—Terminal Box, Brook's System. Elevation and Section.

In England the Brooks system has been used for a short length in the Keswick central station system. Two single No. 14 copper wires, twice braided with jute, and enclosed in an iron pipe with liquid insulation, are used for connecting the church with the overhead high-tension wires. The Brooks main goes under the graveyard to obviate the use of overhead mains. The wires have carried the full pressure of 2,000 volts for a period of over 14 months.

They have also been used on low-tension work in a large private installation for Lord Windsor, where 500 yards of four strands of $^{37}/_{13}$ are worked two each in parallel as main conductors under the grounds from the dynamo-room to the house, to entirely do away with the necessity for overhead wires. Various other private installations have adopted the system. Besides this, the system has been for many years in use on certain railways in England for telegraph wires with very marked success.

Abroad, Messrs. Johnson and Phillips have just furnished the Hong Kong Electric Light Company with 2,000ft. of the Brooks main for high-tension work in connection with the arc lights for public lighting. These mains are to go under the streets to work with a pressure of 2,000 volts The plant is now in process of erection.

Our illustrations give the details, at quarter full size, of the junction-box and terminal-box shown in perspective last week. The cuts are reproduced from the working drawings and practically explain themselves. Fig. 7 shows details ot the junction-box which is laid under the street level. The exits or glands for the cable are arranged so that they can be packed and can also be plugged inside to prevent oil escaping, if the box is required to be left at any part of the progress of the work. In laying, the cables are drawn through from point to point at these boxes, into which the liquid insulation is afterwards poured, and the lid securely fastened down.

Fig. 8 shows the terminal-box, which stands directly under the switchboard at the generating or at the receiving end of the line. Glands are provided when required in the case shown for two cables and pilot wires.

In this system it is seen that there is no space left for the accumulation of explosive gases, or gases injurious to the dielectric, as might be the case where a solid dielectric is used in conduits or iron pipes; and Messrs. Johnson and Phillips themselves believe that the only other system that could compare on the score of efficiency and permanency with the Brooks mains, is that in which the cables highly insulated with indiarubber or guttapercha are drawn into iron pipes kept full of water.

Experience in America for a period of at least 10 years has already demonstrated that, in the Brooks telegraphic and telephonic mains, the cost per wire in a cable of many conductors is less than the cost per wire insulated with guttapercha or indiarubber, even including the additional charge of conduit-pipe and boxes, or other device.

It has also been abundantly proved at Charlton that mains for the distribution of electric light and power will stand the severest tests that are ever likely to be required with even far higher voltages than at present are anywhere employed.

Probably one of the largest fields of usefulness for the Brooks mains will be in connection with the high-pressure three-wire alternate current distribution for lighting, and for alternate current motors, of which the installation to transmit several hundred horse-power a distance of 12½ miles at 25,000 volts, now being erected at the Oerlikon Works, Zurich, is the first and most noteworthy example. Examples of the use of underground transmission in towns where overhead wires cannot be employed will probably not be long in being seen in practice. The details of the Brooks mains for this system have already been carefully worked out, and details will be given of this interesting system next week.

(To be continued.)

LAUNCH OF THE FIRST GOVERNMENT ELECTRIC PINNACE.

On Tuesday afternoon the first electric pinnace constructed for the British Government was launched at the Chiswick works of Messrs. Woodhouse and Rawson, Limited. The event is of somewhat peculiar importance, as though electric boats of larger size have been running for some years and are fairly familiar to the boating public, yet the official and Governmental recognition of the electric launch as of actual practical utility for transport of soldiers and other similar purposes in our naval dockyards has only just been given in the case of the pinnace constructed by Woodhouse and Rawson.

It will be remembered that Mr. Sargeant, who designed for another company the largest electric boat yet made, has lately joined Messrs. Woodhouse and Rawson as manager of the launch department, and the works at Chiswick have already been considerably extended.

The late terrible weather, with fierce wind and snow, did not conduce to the pleasant aspect of road and river that the few days before seemed to promise, and cold and bleak was the outside appearance of the Thames, while inside the boat-building works (which are just beneath the iron railway bridge at Putney) Press representatives, engineers, members of Woodhouse and Rawson, boating-men, and the workmen and launch-builders crowded round the vessel whose first dip was to take place.

The first Government electric pinnace is a very neat, well and solidly built open boat, 48ft. 6in. long by 8ft. 9in. beam, constructed of mahogany with teak fittings. She is built to carry 40 soldiers, and nearly the whole of the inner space is open, with seats around, under which the storage cells are placed, the total draught being 2ft. 3in. when loaded. All machinery is out of sight, nothing save the double-bladed screw and the switch-handle being visible. The boat is fitted with 70 cells; those now used are E.P.S., but it is intended to fit her with a new type of cell—the "Epstein"—on which Mr. Epstein, accumulator manager for Woodhouse and Rawson, has been at work for some years, with, it is stated, extremely successful results. The new cells are of corrugated or grooved solid lead, *chemico-electrically* treated, and, we are told, of about one quarter the size and 25 per cent. lighter than the ordinary lead cells. If this is so, no doubt further particulars and tests will be forthcoming.

For the first trial, however, the ordinary storage cells are used; there are 70 cells of 19 plates each. The E.M.F. is therefore 140 volts. The motor is of a special make by Woodhouse and Rawson, of high efficiency, and made to sit very low on its bearings. It gives 5½ h.p. to 6 h.p. at full speed, the screw being 22in. across, working at 750 revolutions. The switch is arranged to allow full speed and half speed respectively ahead or astern. The charging current for the cells is 35-40 amperes during six hours, and the discharge at full speed 30-32 amperes, and at half speed 19 amperes. The specified speed is eight knots an hour on the measured mile under full load, or about 10 miles an hour. The boat can run 10 to 12 hours, and can go from her present moorings to Chatham Dockyard with one charge. There is no need of any engine driver or mechanic—anyone who can be trusted with an ordinary boat can run her. For cases of emergency she is fitted with two masts, two balanced lug sails, and a stay sail, thus enabling her to be sailed or electrically propelled according to circumstances. She will turn with head up to the wind and stay there. The total weight is 4¾ tons, of which 2½ tons are cells and machinery. The price is about £550 to £600.

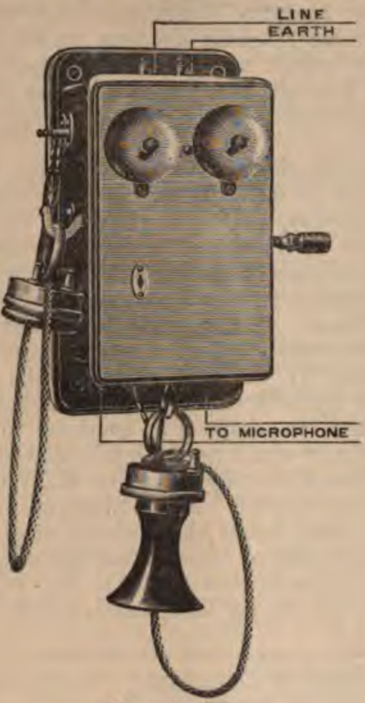
On the day of the launch, the time of which was settled for 1.30 p.m., the strong wind had delayed the tide so much that it was at least an hour after the specified time that the water rose high enough. The crunching of screw-jacks, and the heavings of crowded shoulders, accompanied with lusty cheers, finally moved the boat down the slips, and sent her splashing into the water—Mr. Sargeant, on the forward deck, with weatherbeaten furrowed cheek and peaked cap, vigorously waving the Union Jack, and cheering his men forward. The boat, which was named the "Electric," rode gallantly out into the river, and was then brought back and filled with visitors desiring to try her speed; a short trip was then taken up and down the river.

The "Electric" was built primarily for the conveyance of troops between Chatham and Sheerness, along the River Medway, and is of almost exactly the same type as the ordinary Government steam pinnace already used. It is expected that the electric pinnace will present considerable advantages over those now in use, as not only is the electric boat always ready at a moment's notice, but its actual carrying capacity is greater for the same size, while no skilled hands or engineers are necessary. It is the intention of the Royal Engineers to make a series of exhaustive tests of the type of boat, and Messrs. Woodhouse and Rawson are erecting a charging installation at Chatham, at which the charging will be simple and purely automatic. The company are expecting considerable orders for this class of boat for employment in connection with the large ocean-going steamers, which already have electric installations on board, and would be able to make great use of an easily handled pinnace, either for landing passengers, obtaining provisions, or in case of "man overboard" at sea to have the boat ready and power up at a moment's notice. Messrs. Woodhouse and Rawson have recently opened a second boat-building yard, and a third is expected soon to be opened in the same place. Indeed, their work in boat or launch building, not necessarily electrical, is rapidly extending, and special plant for iron and steel boats is being put down. We were shown a large steel steamboat, 56ft. long, for the Mexican Government, ready for launching. Two Government boats for the Thames have just been ordered, and others are expected shortly to be launched. Besides this, a third electric boat for the celebrated Mr. Pears is in hand, and other electric boats for pleasure or business purposes, an interesting one being the "Delta," an electric launch, built entirely of Delta metal, which will be at Henley this year.

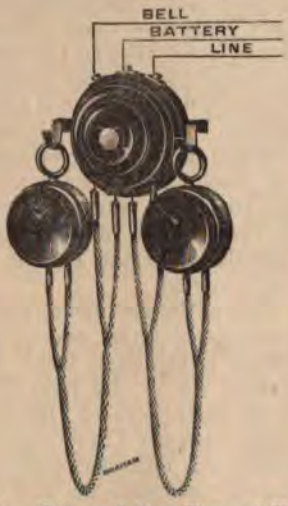
GENERAL ELECTRIC TELEPHONES.

The impetus to telephonic extension that has resulted from the expiry of the Bell patent is continually increasing, and we illustrate to-day a few specimen forms of the magneto instrument that is being introduced by the General

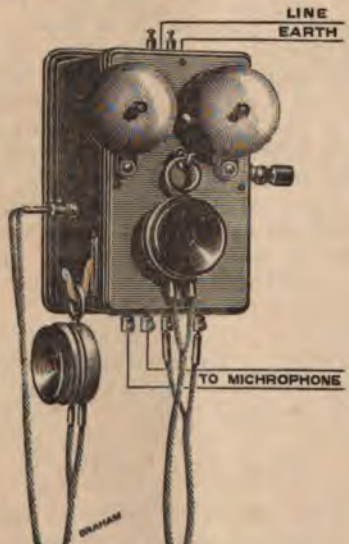
Electric Company. The telephones are neat and handsomely finished, and from actual experience we can testify that the enunciation is clear and distinct through them.



Magneto Set.



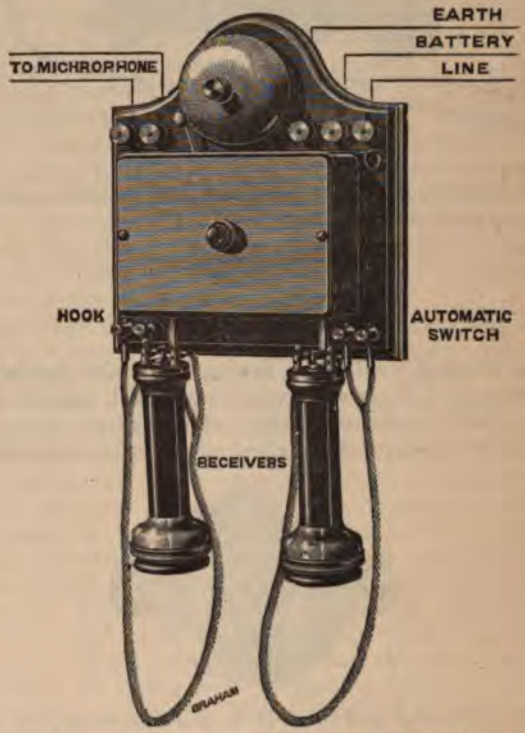
Battery Sets. Bell and Box Type of Telephone.



Magneto Set. Box Telephones.

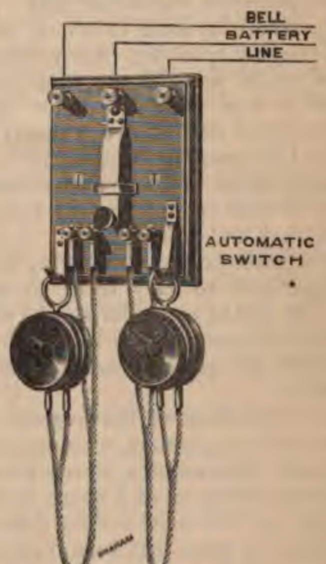
The idea of the introduction of the types shown is the supply of the very wide want for small sets for house and office use, which must arise all over the land as soon as the public realise that they can obtain a telephone set for practically a few shillings. There is no attempt to deal with public exchanges.

The illustrations show various types: the ordinary well-known shape of Bell telephone, or the more modern box or watch case telephone, and these either arranged with a battery and bell or with magneto alarm. Some are also provided with full contacts for a microphone to be connected thereto later on, if desired. Various arrangements are made which explain themselves in the illustrations. One



Battery Sets. Bell and Box Type of Telephone.

Box Telephone.



Automatic Switch.

neat connection is that shown in the automatic switch, where two metal plates are fastened to the hook and the connection is made across simply by the metal ring handle of the telephone. These telephone sets should be well and largely patronised.

Bell Telephone.

CURRENT INDEX.

The frequently-called-for device, illustrated herewith—Hartmann and Braun's current index, which will show at a glance (when in circuit) what accumulators are doing, whether charging or discharging—is a regular speciality of Messrs. O. Berend and Co. It is a well-constructed little piece of apparatus, of high finish and workmanship, and should prove useful on every installation which includes accumulators, as is the case with most separate house installations of present practice.

NOTES ON THE ELECTRIC RAILWAY: HISTORICAL, STATISTICAL, AND TECHNICAL.*

BY FRANKLIN LEONARD POPE.

(Concluded from page 211.*)*

What is termed the commercial efficiency of an electric railway is the ratio between the power generated by the steam engine and that exerted upon the car wheels. We may call the weight of the car body and truck, plus the full load of passengers, the useful load.

The best authorities seem to concur in the opinion that it requires, roughly speaking, nearly twice as much power per unit of useful work done, with the storage battery system, that it does with the direct distribution system. The dead weight of the battery is nearly equal to that of a paving load of 30 passengers, and this load must be transported whether there are any passengers or not. The increased weight adds to the cost of renewals and repairs, both of the track and of the cars.

The cost of horse power for drawing cars has been found by long experience to vary from 10 to 11 cents per car per mile. The cost of power for the 10 storage battery cars on the Madison-avenue line in New York is said to figure out 10·6 cents per car per mile, practically the same as horse power.

A careful computation of the average cost of power by the direct distribution system, on a considerable number of different lines in this country, shows that the cost for coal, attendance, real estate, oil and waste, repairs of machinery and line, foots up 5·09 cents per car per mile.

You will bear in mind that I am now speaking solely of the cost of power; the greater part of the expenses of any street railway company remain substantially unchanged whatever kind of power is used.

We often hear people say, "what difference does it make to us how much the power costs the railroad company? We pay five cents per trip, no more, no less." It is only a question of increasing or diminishing the profits of the corporation. But this is a very short-sighted way to look at the question. Increased economy in conducting transportation means more frequent and less crowded cars, greater speed, more branch lines, and better accommodations in every way. You still have to pay your five cents, it is true, but you must remember that you get a great deal more for your money.

I once had occasion to study this whole question very minutely. In the fall of 1886, when the West End Street Railway Company, of Boston, was first organised, I was commissioned by President Whitney to make for him a careful investigation of the subject of electric propulsion, which he desired to apply to the entire street railway system of Boston. It was a gigantic proposition, for at that date there was hardly a dozen electric street cars running in this country. I was told by him at the outset that I must confine my researches to conduit and storage systems; that anything in the shape of an overhead line was out of the question, and would never be tolerated in Boston for a moment. I submitted my report to Mr. Whitney on the 30th day of April, 1887. At that time no experience had been gained which would enable me to compute accurately the cost of operation of the different systems, but the final result of my estimate then given to Mr. Whitney, of the cost of power per car per mile, was as follows:

Horse power	11·07	cents.
Electric storage system	7·34	,,
Electric underground distribution	6·02	,,
Electric overhead distribution	3·28	,,

It will be seen that these figures estimated the cost of the storage system as a little over twice that of the overhead system. Experience has confirmed the substantial accuracy of my original estimate in respect to relative cost. The absolute cost for all electric systems is considerably greater than was anticipated. This is partly due to the item of repairs for the electric motor and gearing, which are found to be subject to much greater wear and tear than experience had given reason to anticipate, and partly to the great increase in the number of passengers per car mile, caused by the popularity of the electric cars, which adds greatly to the loads carried.

Mr. Whitney then authorised me to construct an electric car operated by storage batteries, and to give the practicability of the scheme a thorough test. This pioneer car, the very first electric car of the West End Company, was put in service in the early part of October, 1887, and was run for some time between Cambridge and Boston. A careful series of tests and measurements showed the cost of operation to be about the same as that of a horse car of equal capacity. The West End Company continued to experiment, putting down, the next year, an expensive conduit line on Boylson-street, in Boston, and an overhead line on the extension of Beacon-street, in Brookline. The comparative results of the practical trial of the three systems was so favourable to the overhead line that the objections of the citizens of Boston were gradually overcome, and at length overhead wires were permitted to be placed in the streets of the city proper.

Finally, I propose to consider the question whether there are any valid reasons why the public should object to the introduction of electric railways, or why the municipal authorities should hesitate to grant the necessary franchises. Are electric railways dangerous?

With a view of getting at the actual facts in the case, the *Boston Advertiser*, a few months ago, sent out a circular letter asking information from every city in which electric railways are in actual operation, from Portland, Me., to Galveston, Tex. It was asked what system was used in each place, whether there had ever been loss of life or injury from the wires, whether there was any serious objection on the part of the public to overhead wires, and what was the general opinion in the locality as to the effect of the introduction of electricity upon the street railway service? Replies were published from 64 cities and towns. All but four of them were favourable. Not one solitary instance of accident or serious injury from electric currents was reported. One of the objecting places was Newport, R. I., where it seems the "upper ten" strenuously opposed the introduction of anything that would popularise riding on the streets.

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* *Paper read before the New York Electric* Club, Jan. 22.

An extraordinary amount of nonsense has been printed and talked in respect to the alleged dangers of both electric light and railway wires. The public have been needlessly alarmed by the exaggerated statements of interested parties; but, nevertheless, the danger is so small, as a matter of fact, that the actual figures are almost astonishing. Most of the accidents which have been reported occurred in New York City. Yet the statistics show that in 1889, out of 1,467 deaths in New York City, by accidents of various sorts, only *nine* were due to electricity, a considerably less number than were killed by being run over by horse cars. Not a single death was recorded in Boston, although there are perhaps more wires there in proportion to the population than in New York. There are in the six New England States nearly 140 arc light stations, burning over 20,000 arc lamps and distributing 30,000 horse-power of electricity through the streets of the principal cities and towns. During the last 10 years, as far as I can ascertain, there have been but five deaths from electricity; four of these were employés of the lighting companies, and one was a careless boy who climbed upon a shed and took hold of a wire. During the same 10 years the steam railroads of New England have killed 2,349 employés and 2,902 other persons; 5,241 against 5. Not only is electrical power far less dangerous than the same quantity of power used in other industries, but it is relatively safer, as the few accidents that do occur are among the employés. These remarks refer to electric wires in general. Now as to electric railway wires:

I believe that it is an incontestable fact that not one single man, woman, or child has ever been killed or even seriously injured by a 500-volt current, which is the highest pressure ever permitted upon electric railway wires. Every alleged case of accident by railway wires has, upon investigation, proved to be either without foundation, or to have been caused by an electric light current. When we consider that shocks have been experienced by men, women, and children; persons of all ages and all sorts of physical condition, sometimes for a period of several minutes, experience seems to warrant the positive assertion that the electric railway current is not dangerous to human life, and that we may dismiss that question from further consideration.

Many person are alarmed at the vivid flashes of light which are often seen at night beneath the wheels of an electric car, and at the point of contact of the trolley wheel with the overhead wire, and are under the impression that they must indicate a very dangerous electric pressure. Such, however, is not the case. In an electroplating establishment at Ansonia, Conn., I once saw a workman accidentally set a tin pail filled with water upon a pair of electric conductors near the dynamo. The pail instantly disappeared, being not merely melted, but being converted into metallic vapour, with a terrific flash which illuminated the whole building with a dazzling and instantaneous radiance; yet the current which produced this startling phenomenon was of such low pressure that it was impossible to detect its presence by the sense of touch, even by applying the hands directly to the conductors.

The average speed of the horse car is about six miles per hour. The question is sometimes asked, How fast may electric cars be safely run in a city street? One fact within my own knowledge will go far to answer this question. There is a heavily travelled street in Pittsburgh only 36ft. wide, containing a double-track cable road, which leaves not more than 9ft. space on each side. At first the cable cars were run at the rate of seven miles per hour; afterwards the speed was increased to 9½ miles per hour. The records show that there are not so many accidents under the present arrangement as there were before. Pedestrians and drivers are more careful and take fewer chances. The schedule rate of the electric cars in Cleveland is nine miles per hour, and in some parts of Boston as high as 12. The value of an electric railway to the public is largely determined by its speed, but the economical aspect of the question is equally important. If we make six miles per hour with horses, and nine with electricity, each car does 50 per cent. more work without increased expense for conductors' and drivers' wages, which is an important item. Another economical feature due to the use of electricity is the ability to haul one, or even two, tow cars without loss of schedule time on special occasions when the traffic is unusually great.

Nothing is more astonishing than the capacity of the electric cars to make their schedule time in the face of the heavy storms of a New England winter. It is a common sight to see an electric car running, apparently with perfect ease, up a heavy grade through snow a foot deep, pushing or pulling cars loaded to their utmost capacity.

The total number of electric cars now running in this country is probably between 2,500 and 3,000. Of the whole number, I presume not more than 30 or 40 are operated by storage batteries. The fact that the overhead system, though introduced at a later period than either the storage system or the underground distribution system, has so far surpassed them both, goes far to show that as yet it is the only system which has been able to meet the various exacting requirements of our street railway service.

I regret that the necessary limitation of time does not permit me to mention more at length the work of other American inventors, to whom the development of the electric railway is largely indebted. Among them are Charles J. Van Depoele, of Chicago, now with the Thomson-Houston Company, at Lynn, who exhibited a car in operation in Chicago, in 1883; Leo Daft, whose motor drew a full-sized passenger car over the Mt. MacGregor railway at Sarotaga, in 1883; and especially Lieut. Frank J. Sprague, who designed, carried out, and completed the first installation of electric railroading on a large scale in the world, in Richmond, Va., in 1888. This was a road 12 miles in length, with a great number of curves, a bad track, numerous grades of 10 per cent. and over, and an equipment of 40 motor cars. Labouring under enormous difficulties and drawbacks, Lieut. Sprague succeeded, by the completion and operation of this plant, in establishing beyond peradventure the future supremacy of the electric street railway, and many of the characteristic features at that time designed and introduced by him have practically become standards in the modern system, and are found in nearly everyone of the thousands of cars now in service.

The limits of time compel me to content myself with the briefest possible reference to the most important development of electrical transportation which has yet come before the public—the electric underground railway. This undertaking having been placed in the hands of electrical engineers whose competency cannot be questioned, and backed by ample capital, has proved in London a phenomenal success. We are now assured that a syndicate of the most prominent capitalists of New York have undertaken to establish a system of transportation upon the same plan, consisting of a network of tunnels at a depth of 100ft. beneath the surface, and connecting all important points, not only in the city itself, but in the adjacent sections of Long Island and New Jersey. In such a system it necessarily follows that the train must be run by electricity to the exclusion of any other power.

Every thoughtful person realises that something must be done at once, not only to relieve the congestion of traffic which already exists in the streets of New York, but to provide for the enormous yearly increase which must be taken into the account. Statistics show that the traffic of the horse cars and elevated lines in New York has increased 46 per cent. within the five years from 1884 to 1889. A careful estimate which has recently been made of the movement of passengers in and about New York during the year 1890 gives the following amazing result:

New York City (surface and elevated roads)...	400,000,000
Brooklyn Bridge	38,000,000
Long Island ferries	90,000,000
Staten Island and New Jersey ferries............	85,000,000
Total	613,000,000

If the profit derived from carrying these passengers amounts to only one cent each per trip it nevertheless figures up to the snug little sum of 6,000,000dols. per annum, which makes a very comfortable dividend upon a capital of 100,000,000dols. Such a system would admit of the running of solid trains at very short intervals through the city, to and from all points in the suburbs, in every direction, and I venture here and now to predict that within the next 20 years, if not the next 10 years, electrical underground transportation will be brought to such a state of perfection that a passenger entering one of the central stations of New York may be deposited at his home station at any point within a radius of 10 miles in 15 minutes time and at a fare of five cents. And the magnificent result is to be the contribution to the convenience and the prosperity of the public of the electrical engineer.

LITERATURE.

"**Intensity Coils: How made and how used.**" By DYER. Sixteenth Edition. London: Perkin, Son, and Rayment.

A book that has reached a sixteenth edition, and which has been before the world for many years, must contain information that is wanted. The Ruhmkorff coil has become one of the most interesting pieces of apparatus in electrical engineering in its comparatively recent development, known as the transformer. This book shows very clearly the historical views held about the coil, and from the amateur constructor's point of view is most valuable, in that it explains clearly how to make and how to use a coil. A great many lecture experiments are described. Although the preface of this edition states that "opportunity has been taken to make some additions" to the book, it may be pointed out that the portion devoted to dynamos is hardly up to date, and that "seeing by electricity" is at the present time quite in the clouds. We would suggest that future editions should be restricted to the dealing with coils and transformers.

UNDERGROUND CABLES.*

BY STUART A. RUSSELL.

The subject of this lecture, as announced to you in the programme, is one that covers a great deal of ground, and were I to attempt to treat it in its widest sense, I am afraid it would require a much longer time than could possibly be given to it in one evening. I propose, therefore, to confine my remarks more especially to the subject of underground insulated conductors, as used for the distribution of electrical energy from central stations.

As you all know, the insulated conductor is the connecting link in a system of electrical transmission between the generator of the current and the apparatus where the electrical energy is to be converted into other energy, whether of motion, light, heat, or chemical action. It consists always of two parts whose functions are for the one to offer as little resistance as possible to the passage of the current along a certain defined path, and for the other to offer as high a resistance as possible to the escape of the current from that path by any other way.

All known substances are to a greater or less degree conductors of electricity, but it is usual to speak of them as divided into two distinct classes—those offering little resistance being called conductors, and those offering a high resistance being called insulators. Amongst conductors are classed all metals and their alloys, carbon, acidulated water, and many metallic solutions; but it is only with the first of these that we are concerned, and of the metals practically only two are used—viz., iron and copper; the first being used for overhead telegraph wires and such like purposes only, whilst the latter is always used for the conductors of cables for electric lighting, and other purposes where large currents have to be transmitted. A great variety of substances are used as insulators according to the particular conditions to be fulfilled, the most important being air, wood, slate, porcelain, glass, mica, ebonite, silk, cotton, and other fibrous materials, guttapercha, indiarubber, waxes, oils, and resinous and bituminous compounds.

In one form or another most of these have been tried as insulating materials for electrical conductors, and we, at the present time, have occasion to be thankful to telegraph engineers, in that they by their 40 years' experience of underground work have shown us many methods of insulating conductors which should be avoided, and have given us many hints as to the most likely direction in which we may find success. I do not wish it to be thought that I consider the cable which is best for telegraphic purposes is also best for electric lighting, since the conditions of usage are very different, but rather that, making due allowance for the difference in working condition, much valuable information may be gained from a study of the history of underground telegraph wires.

Before describing the several kinds of cables most frequently used, it will be well to state briefly what are the requisites of a perfect cable. In the first place, the conductor should have as low a resistance as possible for a given weight per unit of length, which means that the copper should be pure, and in this respect we cannot expect to make any great advances, as copper wire can now be obtained commercially which has 98 per cent., and, in some cases, over 100 per cent. of the conductivity of the standard of Matthiesen, which was supposed some few years ago to be the nearest approach to chemically pure copper that could be obtained in the laboratory. The conductor should also be flexible, and this condition is met by forming it of a number of small wires stranded together, instead of a solid wire. The insulating material used must have a fairly high specific resistance; it should be homogeneous and waterproof; it should be mechanically strong and not easily abraided; it should have sufficient cohesion to prevent the conductor sinking through it at high temperature, and should be flexible, so that it will not suffer damage from bending even at low temperatures, and, most important of all, it should be durable, physically and electrically—that is to say, that it should, under all conditions of temperature and other surroundings, retain unimpaired whatever good qualities it possessed when new for as long a time as possible. In addition, the weight, bulk, and cost of the finished cable should be as small as possible consistent with the due fulfilment of all the requirements named above, and the cable should be so constructed as to allow of joints being well and easily made, without reducing appreciably its insulation resistance per unit length. I am afraid that at the present time no cable fulfils all these requirements satisfactorily, as the best cables are, in the opinion of many, too costly, and the cheaper cables fail in several particulars to come up to the required standard.

The insulated cables which are in use at the present time may be divided into two classes: (1) Those which depend for the retaining of their insulation on a water-tight metallic covering outside the dielectric proper; and (2) those in which the dielectric is itself supposed to be waterproof, and which are therefore independent of any such metallic covering. In the first class are included all cables in which fibrous material, such as jute, hemp, or cotton, impregnated with an insulating compound is used, and such cables are made by the Fowler-Waring, Berthoud-Borel, and Callender Companies, by Siemens, and many American and continental manufacturers, and also by others whose names are more generally known in connection with other methods of insulation.

The Fowler-Waring cable is insulated by wrappings of jute or flax impregnated with a hydro-carbon compound, said to be a residuum of petroleum, and then coated with lead by the cold process.

In the Berthoud-Borel cable the conductor is wrapped with spiral layers of cotton, and boiled in a mixture of linseed oil and resin, and then covered with lead by the hot process. This lead-covered cable is then wrapped with compounded tapes, and a second lead covering put on.

In the Callender cable the conductor is wrapped with jute, and boiled in bitumen. It is then wrapped with parchment tape, and covered with lead by the cold process.

The Siemens cable is insulated with jute, impregnated with a compound called by the makers "caoutchicine," and then covered with lead by the cold process.

In all these cables the lead covering is protected by being served with jute or tapes treated with a compound such as asphalte and tar, or similar material, and when they are to be laid in the ground and not in a conduit, the cable is armoured over all by iron wires or tapes. The Siemens cable, which is always laid in this manner, has two reverse laid layers of iron strip put on spirally, outside which again comes a serving of compounded jute. The joints in these cables may be made by soldering the copper in the usual way and then wrapping the joint with prepared tapes. After this a sleeve of lead, previously slipped over the end of one of the lengths of cable, is passed over the joints and fixed to the lead coatings on either side by wiped joints. This sleeve has a hole made in it near the centre, through which insulating compound is passed to fill up all spaces and make the joint solid. In some cases this method is not followed; for instance, the joints in the Siemens cable are made in special joint-boxes made in halves. The outer coverings of the cable are stripped off and the conductors clamped together, not soldered. The two halves of the box are then bolted together so as to enclose the joint and to grip the cable tightly at each end where it enters. The box is then filled with a heavy insulating oil through a hole at the top, which is afterwards stopped by a screw plug. The Callender cable is also sometimes jointed by clamping the conductors together inside a box which is made as water-tight as possible.

From the above description it will be seen that the differences existing between the cables of various makers are in the insulating compound, the exact nature of which is kept a secret, so that discussion of their relative values is not possible; and in the method of putting on the lead covering. The two methods which I have called respectively the hot and cold processes differ in this way. In the hot process the lead in a molten condition passes out through a die, in the centre of which moves the cable to be covered, whilst in the cold process the lead at a temperature far below its melting point is forced through the die by the application of great pressure. This latter process, therefore, has the advantage that the lead covering is put on under considerable pressure, and is therefore less porous and stronger than when put on by the hot process, and also that the covering is much more uniform in thickness since the lead does not allow of the covered conductor sinking into it in the way that it does in the hot process.

In all cables of this class it will be seen that the original value of the insulation resistance is dependent on the complete expulsion of all moisture from the fibrous material, and that the permanency of the insulation can only be maintained by keeping the fibrous material, which is very hygroscopic, from contact with moisture by an air and water-tight casing. Although great improvements have been made in the manufacture of cables of this class, they are still in my opinion open to the following objections :

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* *Lecture delivered before* the Woodhouse and Rawson employés' *class, March 6, 1891.*

1. Since the insulation depends on the thoroughness with which the moisture is extracted, and this is done by the application of heat which greatly weakens the fibrous material, there is the danger of damaging the fibre or not completely drying it. So far as my experience goes, the success attending this operation is not uniform, so that cables which should be similar do not test the same, and it would therefore appear difficult to decide whether an insulation resistance which was below the average was due to a uniformly lower specific resistance, or to a local fault which ought to be removed.

2. Slight flaws in the lead covering, even if small enough to escape detection as mentioned above when the cable is tested in the factory, will in time lower the insulation resistance considerably.

3. The lead covering is more liable to be damaged by bending and coiling and uncoiling from drums than a flexible insulating covering, and the lead-covered cable is not so easily handled, owing to its being less flexible and more weighty and bulky than cables without metallic covering.

4. Owing to the hygroscopic nature of the fibrous material, there is great risk of the insulation resistance being lowered whenever the leading casing is opened and a joint made.

5. The dielectric not being homogeneous, and the component parts having different rates of expansion, the existence of cracks and fissures is probable, and these cracks offer easy paths for disruptive discharge. Owing to the trouble due to this cause in arc light circuits in America, it was found necessary to double the thickness of the dielectric, making it $\frac{3}{16}$in. instead of $\frac{3}{32}$in.

6. In some soils the lead covering has been found to perish very quickly, due to chemical action, and the destruction of the lead at once causes faults in the cable.

For the second class of cables the insulating material should itself be waterproof, and amongst the substances tried for this purpose are nigrite, kerite, and okonite—all of which are better known in America than over here—bitite, guttapercha, and indiarubber. The first three are all mixtures of rubber with some other substance, the exact composition of which is a secret, and they have all been used with varying success in America for underground work ; but, so far as I know, none of them have yet been tried underground in England.

Bitite, which is the insulating material used by the Callender Company, is said to be bitumen absolutely refined to purity and vulcanised. This class of cable has been used a good deal underground for low-pressure systems, and in one or two instances for high pressure. Personally, I have had no experience of the use of this cable ; but from my general knowledge of bituminous substances, and from particulars given in the press, I should expect to find that the specific insulation resistance was low, and that the conductor was liable to uncentre owing to insufficient cohesion in the insulating material.

Guttapercha, for many purposes the best insulating material that can be got, has earned a justly high reputation for all submarine work ; but for the generality of electric light work it is utterly unsuited, as it does not stand exposure in a dry atmosphere or changes of temperature, becoming brittle at a temperature of between 30deg. and 40deg. F., and softening at about 100deg. F. In fact, the situation as regards guttapercha may be summed up by saying that when of good quality and properly applied, it can hardly be excelled if kept in water at a temperature of from 40deg. to 80deg. F., but that under any other circumstances it takes a much lower place in the list of insulating materials. It is, however, as you no doubt know, used to a very great extent by the Post Office and others for underground telegraph and telephone wires ; and for this work, when the conductor is light, the heating due to the current negligible, and the cable kept at a fairly constant temperature in a moist atmosphere, it gives very satisfactory results.

The insulating material of which I have most experience is indiarubber, and, in my opinion, it is the one from which the best results are obtained. This opinion, if we put on one side the question of price, is, I believe, pretty general, as practically the only objection to the use of good rubber cables is that they are expensive. Indiarubber-insulated cables are made in various ways, and of very different qualities, and it is therefore necessary to distinguish between the several kinds of cable, and to put certain limitations on the general statement made above. At first used for electric light work, a rubber cable consisted of a conductor around which was lapped spirally one or more layers of pure rubber tape, and on this a protective covering of tapes or braiding. This class of cable, although it has done very good work in internal wiring, is not satisfactory for use out of doors, since the covering is neither homogeneous nor waterproof, nor can a sufficient thickness of it be put on, without excessive cost, to stand the mechanical strains of handling. The rubber, in the form of pure tape, is also very susceptible to changes of temperature, and the decomposition which always takes place in unvulcanised rubber is much helped by the application of heat. The statement just made that a pure rubber cable is not waterproof, has been combatted on several occasions, and tests of this cable in water have been quoted. It is quite true that such a cable can be made to test in water by warming it, which makes the adjacent strips of rubber stick together ; but when this is done it is at the expense of the durability of the rubber, as this very tackiness which causes the strips to stick to one another is one of the first results of decomposition.

The next step made in the manufacture of rubber cables was to use a compound rubber instead of pure rubber, and although at first sight this may appear a retrograde step, yet it really was a considerable advance, as, in the first place, it allowed the rubber to be put on the conductor as a continuous coating, and under pressure, which made a much more homogeneous covering than the pure rubber; and, secondly, it allowed a greater thickness of the material to be used without the cable becoming excessively costly, the result of which was that the compound rubber cable was able to withstand handling and rough usage much better than one insulated with the usual amount of pure rubber. As regards durability there was, however, still something to be desired, as even the best compound rubbers were liable to injury by extremes of heat and cold, though in a less degree than the pure rubbr, and were liable to become either too hard or too soft according to the mixture used and to the treatment of the cable, thus losing their flexibility. These physical changes naturally brought with them electrical changes, which were shown by a falling off in the value of the specific insulation resistance.

Cables such as I have been describing were, however, thought to be sufficiently good for all the requirements of the work done until a few years ago ; when, owing to the increase in the amount of electric lighting work, to the use of higher pressures, and to the necessity of laying cables underground, a demand began to arise for a more perfect and more durable type of cable, and to comply with this the vulcanised rubber cable was produced. Looked at in the light of our present knowledge, it seems strange that we should have been content with the older types of cable for so long, since the use of vulcanised rubber was no new thing ; indeed, except for the electric light cables, it would have been difficult to find any manufactured rubber articles where the rubber was not vulcanised ; and even so long ago as 1868 the necessity of treating the rubber in this manner was recognised, when it was used as the insulating material of the core of a submarine telegraph cable. I speak under correction, but I believe that the first instance of cables of this class being used for electric light work was in 1885, when two ships were wired for Messrs. Harland and Wolff with vulcanised rubber cables by the Silvertown Company.

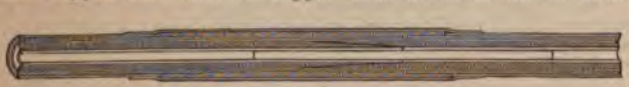
Vulcanisation is brought about by mixing a small quantity of sulphur with the rubber, and submitting the mixture, under pressure, to a temperature of about 300deg. F., when the sulphur combines chemically with the rubber, and thereby neutralises the effects of certain solvents, which, so far I know, cannot be otherwise got rid of.

This class of cable, as now generally manufactured, consists of a stranded conductor of tinned copper wires, around which is first lapped a coating of pure rubber. One or more coats of vulcanising rubber are then put on under pressure, according to the thickness of dielectric required, and the core thus made is tightly lapped with prepared tape. At this stage it is removed to the cures, where the rubber is vulcanised, and then, after being tested in water to see that the rubber covering is mechanically perfect, and of the proper quality, the core is taken to the braiding or taping machines, where the outer covering of compounded cotton, flax, or tapes, which is designed to protect the rubber from injury, is put on. It is this last form of rubber cable which, when first-class rubber is used, well mixed, put on under considerable pressure and carefully vulcanised, gives, in my opinion, better results than any other kind of cable which has yet been produced. Such a cable gives a high and uniform insulation resistance, and the insulating material is waterproof and homogeneous, is sufficiently tough to prevent the conductors from uncentreing, stands a high temperature without softening, is flexible and will stand handling and bending about without injury, and, finally, is very durable. When used for out-of-door work the utmost care should be taken in making the joints, which should always be vulcanised, and when this is done by experienced men the cable with its joints should still test as high per unit length as the separate pieces of cable before jointing.

A good method of making these joints is as follows. The copper joint should be carefully soldered with resin as a flux, and finished smooth and clean. The ends of the rubber which have been exposed during the making of the copper joint should then be pared down to as long a taper as can be made. The bare conductor and the tapered surface of the rubber is first lapped tightly with one or more layers of pure rubber strip, and then with one or more layers of vulcanising rubber, care being taken to lap the rubber so as to exclude air. The joint thus made is tightly bound up with prepared tape, is then covered by a piece of sheeting, making a longitudinal seam, and firmly bound round with selvedge tape. The sheeting and selvedge tape act as a mould to keep the joint in shape during the vulcanising process, and are removed again when this is completed. The bottom half of the cure, which is a cast-iron box with a bolted cover, and having cylindrical openings at each end, is then placed under the cable so that the joint is wholly within it. The cable, where it passes through the end openings, is wrapped with common rubber to protect the original insulation from heat, and to make tight joints at the openings, the cover is bolted on, and molten sulphur is poured into the cure through a hole in the cover. The sulphur is heated by one or more spirit lamps placed under the cure, and the temperature is noted by a thermometer placed in the molten sulphur, and projecting through the hole in the cover. For the rubber used by the Silvertown Company, the temperature should be maintained at about 290deg. to 300deg. F. for half an hour. The molten sulphur is then run out through a tap in the bottom of the cure, the cover removed, and the joint taken out and the wrappings stripped off. A rough test of the success of the process may be made by indenting the rubber when cool with the thumbnail. The rubber should be springy, and yield to the pressure, but no mark should be left. If the mark of the nail remains in the rubber, or the rubber is hard and unyielding, the joint is not a good one. If good, the joint is finished by lapping it with prepared tapes extending a couple of inches or so over the original braiding on each side of the joint. If the hands are kept dry and clean, and care is taken that the surface of the original insulation is clean, and that the new rubber is applied so as to squeeze the air out before it, joints of this kind present no great difficulties. For outdoor work a good-sized jointers' tent should always be provided, so that the jointer and his work may be protected from dust or rain.

I now propose to describe another class of insulated conductors, which, although they cannot be called cables, are yet supplied insulated and protected from the factory. They differ from the cables in that they are supplied in short rigid pieces, which are jointed together as they are laid. The first example of this class, and one which has been extensively used for many years for the low-pressure three-wire systems, is the Edison tube. The conductors are solid copper rods, which are first spun over with dry string, and then placed three together in the proper positions in the centre of a steel tube. This tube is then connected to a pump, and a vacuum created, after which a hot bituminous compound is drawn in to fill up all the space in the tube which is not already occupied by the conductors. These tubes, which are about 20ft. long, are laid in the ground, and are connected together by split junction-boxes, which embrace the steel tube. The copper conductors, which project a little at each end beyond the tube, are connected by short lengths of flexible copper cable, the box is bolted up tight, and filled with hot bituminous compound. Where branches are taken off, T-shaped boxes are used, and the same method of jointing and insulating is followed.

Another example of this class is the Ferranti concentric main which has been laid to convey the high-pressure current from Deptford to the transformer stations from which the distributing network starts. This main consists of an inner tube of copper about 20ft. long, and $\frac{13}{16}$in. external diameter, on which are wound layers of brown paper, steeped in a hot bath of special wax, until the diameter is about $1\frac{7}{8}$in. This insulated tube is then slipped into another copper tube which is drawn down through a draw-plate till it fits tightly over the insulation. The outer tube is then insulated in the same way with prepared paper to a thickness of rather less than $\frac{1}{8}$in., and is slipped into a steel tube provided with a hole in the middle of its length. Hot wax is then forced by a pump through the hole, so as to drive out the air and make a solid mass between the outer copper tube and the steel tube. The tube is then taken to the lathe and the ends are turned to a 6in. taper, one end male, the other female. At one end a solid copper rod, about 18in. long, is driven half its length into the inner tube, and a sleeve of copper is slipped over the outer copper tube and fixed in place by being corrugated, so as to form two or three circumferential indented rings.



Ferranti Joint.

(To be continued.)

BRISTOL.

The following is the report of the Electrical Committee presented to the Town Council last week and adopted last Tuesday:

Your committee remind the Council that on the 10th June last they presented a report to the Council, recommending the Council to take steps for lighting experimentally the area included in Schedule A to the Bristol Electric Lighting Order, 1883—viz., Clare-street, Corn-street, Wine-street, Broad-street, and High-street—and that the Council resolved that it was desirable that the Corporation should keep the control of the supply of electricity for lighting and other purposes in its own hands, and that the report be referred back to your committee that they might advise the Council as to the desirability of adopting a scheme for lighting a larger area than that suggested by the report and for supplying private consumers with electricity. Your committee have given the subject so referred to them their earnest consideration, and now advise the Council that the area to be at first lighted should be extended, so as to include, in addition to the area in Schedule A, the following streets and places—viz., Victoria-street, Bristol Bridge, Baldwin-street, St. Augustin's-parade, College Green, Park-street, Queen's-road to the Victoria Rooms, Union-street, Dolphin-street, Peter-street, Castle-street, Old Market-street, Small-street, and Bridge-street, and they have obtained from Mr. W. H. Preece a descriptive report of the best method of lighting the area and of supplying electricity for private lighting in the neighbourhood, and an estimate of the cost. The report and estimate, together with a plan of the area to be lighted, are submitted herewith. The installation recommended by Mr. Preece is intended only as a commencement, and is so designed as to be capable of future extension to every portion of the city to which it may be considered desirable to extend electric lighting. Your committee recommend that the alternate-current transformer system, which is available for motive power as as well as for lighting, be adopted for electric lighting by the Council: That your committee be authorised to carry out an installation, upon that system, capable of supplying electricity to 100 arc lamps for street lighting, and 10,000 glow lamps for private *lighting, in the area shown in* the plan, at a cost estimated not to *exceed £66,000; to obtain tenders* for the necessary machinery and works; and to employ such professional and other assistance as they may require. Your committee consider that the most suitable site for the erection of the central station is a block of properties belonging to the Corporation, and situate in Temple-backs, near St. Philip's Bridge, and your committee, with the concurrence of the Finance Committee, have arranged for vacant possession on the 25th inst. of the central portion of the block, on payment of £250 to the occupiers. Your committee recommend that the whole block be appropriated for the erection of a central station (the central portion, for vacant possession of which your committee have so arranged, being used for the erection of the works necessary to carry out the proposed installation, and the remainder being reserved for future extensions), on terms to be arranged between your committee and the Finance Committee; and that your committee be authorised to remove so much as may be necessary of the buildings, of which possession will be obtained on the 25th inst., and to agree with the lessees and occupiers of the other buildings for possession thereof when necessary. The sum of £66,000 required to carry out the installation may be raised either by borrowing the same upon mortgage of the general district rate and fund, or by the issue of stock, under the provisions of section 52 of the Public Health Acts Amendment Act, 1890. Your committee propose to consider which method will be the most desirable one, and to report thereon at a future meeting of the Council. Your committee recommend that if any surplus should remain out of the sum of £66,000, after carrying out the proposed installation, it should be used in extending the lighting to the top of Stoke's-croft, through Broadmead and North-street.

Mr. Preece's report is as follows:

Gentlemen,—I recommend that a complete electric light installation be equipped in Bristol capable of supplying electrical energy to light up at one and the same time 100 arc lamps for public street lighting, 10,000 glow lamps, each of 16 c.p., for private and internal lighting. This means the provision of boilers and engines capable of developing 1,200 i.h.p. with dynamos, and all the requisite instruments and mains to convert this power into the form of electrical energy, and to distribute it continuously from a single central station to be erected along the water side in Temple-backs. The public lamps will be distributed throughout the district selected and indicated upon the attached map, but the private lamps may be fixed outside the limits of this restricted district, in fact, wherever within a reasonable area the demand for electric light may arise. I have kept well in view the ultimate extension of the system over the whole of the borough, and my estimates for mains are based on the assumption that the extension will sooner or later be carried out. The site selected for the central station, in Temple-backs, is admirable. The space is ample for the purpose, and being on the water side we shall secure all the advantages of cheap transit in coal and easy disposal of cinders, and a supply of water for engine purposes. In my estimate I have not allowed anything for the purchase and preparation of the site, but I have put down £5,000 for buildings and alterations. I estimate the capital expenditure necessary for carrying out the installation to be £66,000. This is based on the experience of many installations, and it is divided as follows: Buildings, £5,000; machinery and plant, £24,000; mains, etc., £20,000; distribution, £6,000; working capital, £5,000; 10 per cent. for contingencies, £6,000; total, £66,000. The annual revenue to be derived from this installation, regarded as a distinct undertaking, if all the lamps be taken up and used, I estimate as follows: Arc lamps, £2,500; glow lamps, £10,500—total, £13,000. The working expenses will be: Arc lamps, £2,500; glow lamps, £7,100—total, £9,600. Hence the profits would be £3,400, or about 5 per cent. on the capital expended (£66,000), while the selected public streets would have their illumination increased at least fourfold. The number of lamps to be ultimately installed throughout the city and neighbourhood should far exceed 10,000, but 10,000 would be enough for a commencement. Any system of electric lighting lends itself so readily to expansion that when once a central station for the manufacture of electrical energy has been established, it is very easy to enlarge its output as the demand for light increases. The growth of the light in Bristol is certain. There are now in London nearly 200,000 lamps, and they are being installed at the rate of 4,000 per week. At Bradford they have had to nearly double their plant in the first 12 months. At Bath 4,000 lamps are already fixed, although the station has been open for only a few months. At Newcastle 15,000 8-c.p. lamps have been fixed in only nine months, and the demand for lamps is so great that it cannot be met with sufficient rapidity. Thus I regard 10,000 lamps as a modest installation to commence with. Moreover, it seems to be the universal experience everywhere that more than twice as many lamps are fixed as used at one time. In purely residential districts only 40 per cent. of the lamps fixed are alight at one and the same time. In business districts, including offices, theatres, and shops, the percentage is 60. Hence the mean is 50 per cent. in a mixed district. Consequently a plant designed for a maximum load of 10,000 60-watt (16 c.p.) lamps would supply 20,000 lamps wired and fixed; and as 32-watt (8 c.p.) lamps are very much used for passages, bedrooms, and closets, it really means an eventual capacity for 30,000 fixed—half being over 60-watt (16 c.p.), and a half 32-watt (8 c.p.) lamps. The estimated revenue is based on the assumption that each lamp alight and in daily use earns 21s. per annum; which means that each lamp fixed earns 10s. 6d. per annum. The information at my disposal, gathered in visiting the different stations in the country and London, leads to the conclusion that the companies derive an average annual income of 24s. 6d. per lamp alight, or say 12s. 3d. per lamp fixed; but they have to make dividends upon an inflated capital often loaded with promotion expenses and the cost of unsuccessful experiments, while a corporation has no such necessity, therefore 21s. is a moderate estimate. The statistics of the gas industries show that in nine of the principal towns of the United Kingdom the average earning per gas burner fixed is 9s. per annum. Hence 10s. 6d. per electric lamp fixed is a very fair and moderate revenue as compared with gas. The working expenses are easily calculated, and may be taken as being very reliable. They are based on actual experience, and have been checked in various ways. They work out at 14s. 4d. per annum per lamp alight in Bristol; in London the cost is 18s. owing to the greater price of coal and labour. The "bot" is the Board of Trade unit of electrical energy supplied to the user as defined in the provisional order, measured by meter and charged for. The price I suggest for electrical energy is 6d. per "bot," which is 50 per cent. more than gas. But in drawing a comparison between the two we must remember that there is always a great amount of waste in gas. Burners are left alight unnecessarily, because there is trouble in relighting; whereas with the electric light it is used only where it is wanted, and when it is wanted. It requires no match striking; the simple turn of a tap or button brings it out at once into full blaze. Ample experience shows that the average consumption per annum per 16-c.p. lamp in use is 42 "bots," which at 6d. per "bot" will produce 21s. A gas lamp giving the same light, and also in daily use, costs 18s. So, practically, the difference in cost is about 17 per cent. in favour of gas. In Bath the charge is, by contract, based on 1s. per candle per annum, so that a 16-c.p. lamp will cost 16s. per annum. But this is a charge on every lamp fixed, whether in daily use or not. In Bristol each 16-c.p. lamp so fixed will on my estimate pay 10s. 6d. It may be simpler to charge at a price per lamp per annum, but it is fairer to supplier and consumer to charge by meter, and to pay for the actual energy consumed. Moreover, payment by meter is incentive to economy, while payment by contract encourages waste and unnecessary expenditure of coal. In all systems of electric lighting we must have boilers to produce steam, engines to convert steam into power, dynamos to transform power into electric currents, mains to distribute currents over the districts to be illuminated, and lamps to utilise these currents in the form of heat and light. So that, whether we use gas or electricity, we have similarly coal at one end and light at the other. Now one ton of coal will produce 10,000 cubic feet of gas, which under ordinary circumstances will keep a 10-candle lamp alight for 2,000 hours; but one ton of coal converted into electrical energy will keep four such lamps alight for the same time. The relative cost of the two systems is not in their manufacture (where electricity is cheaper than gas) but in their mode of distribution, and in the cost of mains (where gas is cheaper than electricity). It is in economising the cost of distribution that all the recent advances in electric lighting have been made, and it is only within the last year or two that financial success in dealing with extended areas has been assured. This is due to the employment of high pressures, and the practical development of alternate current working. With low pressure and continuous currents, the weight of copper required to be used increases at a rate greater than the square of the distance covered, so that if a ton of copper were wanted for half a mile, more than four tons would be wanted for a mile. Now the same weight per half mile will do if we increase the pressure directly as the distance covered; and, by using high pressures, we can use much smaller conductors, and so reduce the cost of distribution very materially. Indeed, were it not for the sale of residuals, which reduces the price of coal to the gas manufacturer to a very small figure, electrical energy could be supplied cheaper than gas. Even now, in countries where there is no market for residuals, electricity will beat gas in price. The analogy of water explains the salutary effect of high pressures. We can transmit water power either by a small quantity of water at a high pressure, or by a large quantity at a low pressure. The latter involves the use of much larger pipes than the former. So we can transmit a large quantity of electricity at low pressure in large conductors, or a small quantity at high pressure in small conductors. Now, electrical energy is made up of pressure and quantity; and if we use high pressure in our mains, we must reduce it before it enters our homes to low pressure. This is the function of the transformers. The determination of the system to be used is purely a commercial question—we have the choice of (1) the continuous current, low-pressure system, in which the electrical energy is distributed directly by three wires at low pressure; (2) the continuous current, high-pressure system, charging storage batteries, which distribute the electrical energy at low pressure; (3) the alternate current, high-pressure transformer system, exciting transformers at high pressure, but distributing at low pressure. The first system is only applicable economically to compact and restricted districts, and is not suitable to a wide area such as Bristol embraces; for in such districts it means several central stations. The second system is at present very wasteful in energy and costly in working. The third system is the only practical economical system for the Bristol area, and it is the one that I recommend for adoption. High pressure is used to enable the electrical energy generated at a central station to be distributed over a wide and scattered area with economy and efficiency; and alternate currents, as opposed to continuous currents, are necessary to enable us to reduce or transform the high pressures to low pressures, for distribution in houses and premises, so as to secure safety and to utilise the ordinary lamps at present in the market. This system enables us to place the central station in the most convenient and economical locality for cheap coal, water, and the easy disposal of ashes and residuals. We shall require small sub-stations for housing and working the transformers in the different districts served. Cellars or rooms of about 50 square feet are best, and at first we shall want perhaps six. Their position will depend very much on the customers for the light. I have marked their probable positions on the plan. I have provided for the cost of any structural alterations that they may involve, but I have not allowed for any annual rental. This must be very small; £5 per annum per station ought to suffice, and two or three of them would be located on municipal property. The committee have seen the various systems at work in different places, and I think they unanimously arrived at the conclusion that this high-pressure alternate-current system is the best system to use in Bristol. I propose to separate entirely the public lighting from the private lighting. The former is a constant quantity burning from hour to hour without any variation, excepting in the daily consumption due to the change of seasons; absorbing at all times the same amount of energy, easily regulated; all the lamps being lighted and extinguished at the same time. The latter is a very variable quantity, difficult to regulate, and requiring careful supervision. I attach a diagram, which gives the variation of load on different days in a central station in Liverpool, and shows the great changes that have to be provided for in working the private lighting supply. This separation of public and private lighting is very simple. Special and distinct dynamos at the central station will work separate circuits. I propose to use at first, for public lighting only, arc lamps of moderate power (500-watt lamps giving about 1,000 c.p.), fixed at an average distance of about 50 yards apart, and arranged in two circuits along the various streets selected by the committee, as shown upon the map. Along some streets these lamps will be fixed along the kerb in zigzag fashion on high iron posts alternately on different sides of the street; but in several other streets they will be placed about 30ft. high over the centre of the roadway—a system adopted with great success in Milan and Florence, the two most beautifully-lighted cities I have ever seen. At Bath and Chelmsford the lamps are too widely scattered, and the effect is thus very much lost. The illumination along the surface of the streets is irregular. Shadows are too prominent, and parts of the streets are as dark as they were before. But in Florence the illumination is uniform; there are no shadows, and the effect is brilliant. At Bristol I hope to excel even Florence, for I propose to separate the lamps by 50 yards instead of 60, as in the Italian city. The cost of street lighting by electricity can be materially reduced by putting half the number of lights out at midnight, by the mere turn of a switch at the central station; and even when this is done the illumination will be twice as great as it is now with lighting by gas. The popularity of the light in Bristol will depend very much on the brilliancy with which the streets are illuminated. The public expects a blaze of light, and it is very much disappointed if it does not see a material improvement in outdoor lighting. The Corporation must expect to pay more than they are paying now, but it will not cost them much more, and they will certainly obtain a better article, and one that cannot fail to give satisfaction all round. The cost of lighting by gas the selected area is £1,265, and the cost of lighting it by electricity will be £2,500; the extra cost will therefore be £1,235. The introduction of the electric light into household use is very much retarded by the present cost of wiring, and by the disinclination of the tenant to spend money on another person's property. But the cost of wiring is being very much reduced. It ought not to cost more than 20s. per lamp; but it may cost very much more, according to the taste or extravagance displayed by the consumer in the selection of electroliers and fittings generally. The electric lamp lends itself to simplicity, and there is no reason why its installation should exceed the cost of gas-lights and fixtures. The annual cost of the lamp to the consumer must also contain the cost of the renewal of the lamps and the repair of the fittings. An electric glow lamp now costs 4s., and it will last, on the average, 1,200 hours. Lamps burn, on the average, 600 hours per annum. hence they require renewal every two years, which means a cost of 2s. per annum per lamp for renewal at the present price. In two years the patent will expire, and then we may reasonably expect to get our lamps for 2s. or even less. In America, where the patent has been upset, they are now being sold for 1s. 10d. The annual renewal of lamps in the future may thus be taken at 1s. If we allow another 1s. per annum for repairs we can say that each lamp fixed will cost the consumer 12s. 6d. per annum. I do not propose at this stage to specify the character and form of the boilers, dynamos, engines, transformers, and machinery to be used. I do not think we should be wedded to any particular design or patent, but that we should give all manufacturers and contractors a chance to compete for the supply of the plant, either as a whole or in parts. We shall want boiler capacity to furnish sufficient steam for 1,200 i.h.p. engines of sufficient power to drive three alternators of 150 kilowatts each, two ditto of 75 kilowatts each, and three dynamos, each capable of lighting 50 arc lamps; mains and sub-mains laid through three and a quarter miles of streets to cover the area selected and to serve the public lamps; transformers of sufficient capacity to equip six sub-stations; 100 arc lamps with their posts and fittings, and all the various instruments and machinery required to thoroughly fit up a model central station which will be a credit to the Corporation of Bristol. I have provided for spare apparatus to meet emergencies, and I contemplate arranging everything for the gradual growth and enlargement of the system. The area to be lighted is restricted at present; but there is nothing whatever to prevent our extending in the direction of Clifton, Bedminster, and Westbury, when we are in a position to do so. For the valuable assistance rendered by furnishing me with plan and particulars I am indebted to Mr. B. Kitt, the gas examiner to the authority.

THE

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

OVERHEAD WIRES AND CABLES.

The various metropolitan vestries, being the business committees of the various parishes, are interested in all that concerns the due maintenance of the streets. Hence the operations attending the various developments of electricity, encroaching as they do upon the space above and below the surface of the streets, have to be carefully considered, and, where permissible, regulated so as to cause the least inconvenience. Mr. T. W. E. Higgens, the surveyor to the Chelsea Vestry, has presented a report on overhead and underground wires, cables, pipes, etc., which, with the exception of the schedules, is given elsewhere in our columns. Mr. Higgens has done a good work in this report. He has annotated, so to speak, the law on the subject, telling his Vestry in clear language just what the various companies can do and what they cannot, when the Vestry can interfere, and when the companies can act without so much as saying, "By your leave." No doubt some of the members of the Vestry will notice certain points which need elucidation. We shall call attention to one or two that need amplification in order to be thoroughly understood. Consider, shortly, the bearing of paragraph 31, which may be reproduced here. It reads as follows:

> "31. Apart from the scientific difficulty, there is the monetary one. An overhead wire can be fixed at a cost of about £16 per mile, while an underground one will cost £350. If, therefore, telephone companies were compelled to place their wires underground, it would not only mean that the service would be less efficient, but that the cost of using the telephone would be practically prohibitive."

The initial cost is not the only thing to be considered. We grant it is a most important question; but because an overhead wire costs to fix £16, as against £350, the cost of fixing an underground wire, it does not mean that £334 is lost in the one case or saved in the other. Possibly, the gain and loss may really, in the long run, be reversed. Let us see. The life of an overhead wire is given by paragraph 27 as five or six years. Assuming it is six years, that means every six years, not only has the fixing to be renewed, but the wire also. What is the life of a telephone wire underground, say, in a pipe on the Brooks system insulated with mineral oil? Is it six or is it 60 years? There seems to be no reason why it should not be 600 years. Assume the life to be 60 years. The fixing is to cost £350 per mile. But this is paid once in 60 years, while the £16 is paid once every six years, or the overhead wire costs for fixing £160 during the 60 years. To this, however, must be added the cost of the wire itself, which has on the overhead system to be renewed every six years, so that when we consider the cost of 10 miles of wire as against the cost of one on the underground plan, in addition to the above-mentioned £160, the saving by the overhead system is not so great as at first sight it looks.

Further, we cannot agree that these figures are correct as given by Mr. Higgens. The cost of fixing *one* mile of underground telephone wire may be £350, but still adhering to the Brooks system, the cost of fixing 100 or 1,000 wires underground will be very little more than the cost of fixing one wire. This is no new conclusion on our part. When Mr. Brooks was over in England—was it not about the year 1881?—laying an experimental line for the Post Office, the question was again and again discussed. Then our opinion was stated to be in favour of such a system, and that its adoption would partially remedy the evils of cross-talk. If we may accept Mr. Higgens's figures, the fixing of every mile of overhead wires cost £16, whether the streets and supports carry two or a thousand wires. The case is wholly different with oil-insulated wires. A thousand wires may be drawn into one pipe, each insulated from the other and doing its own work, while, as we say, the cost of fixing the thousand wires is little more than the cost of fixing one wire. The telephone company that has monopolised London had a splendid opportunity of testing the correctness of these views, but they have clung to overhead work, and earned the anathemas of everybody with whom they have had dealings. Unless we are greatly mistaken, the Americans have satisfactorily tested the system. The position of the law is such that, obtaining wayleaves, the telephone companies are practically masters of the situation. They can go where they like provided the wire is not an obstruction, dangerous, or a nuisance (paragraph 8). It really is all "three," but everybody's business is nobody's, so the overhead wires go on. The companies may not be permitted to lay wires underground (paragraph 9) without an Act of Parliament, but the proper thing to do is to get an Act of Parliament.

Mr. Higgens properly calls attention to "dead" wires—that is, wires no longer in use. These are left, to deteriorate in many instances at their own sweet will, to break and tumble about without any one troubling in the matter. Surely, as the air above us gets crowded, like the soil under our feet, the danger, small as it is, from a single wire will increase, till a tangle of breaking wires will cause an accident that will arouse the population to a nine days' craze of fury. Of all the people in the world we English are about the most dilatory. We have an axiom that a "stitch in time saves nine," but it needed a repetition of murders to get a "means of communication" in a railway carriage, and a mean means it is. It needed accident upon accident to get continuous breaks. What it will need to prevent accidents from overhead wires, the next generation may be able to say—this one as yet cannot. If Mr. Higgens's report were sent broadcast to every local authority in the kingdom, each clause discussed in a broad spirit, and concerted action taken with the Board of Trade, the remedy would be short, sharp, and effectual. It will be gathered from our remarks that we cannot altogether agree with clause 30, which says "overhead wires are a great public convenience." In populous, busy centres, no overhead wires; though in less populous districts they may be tolerated. We have, then, intended to call attention primarily to two points: (1) that the mere statement of cost of fixing overhead and underground wires is no criterion of the real gain or loss; (2) that powers are required for dealing with "dead" wires.

CURRENT LITERATURE.

We are pleased to hear from Prof. Silvanus Thompson that the announcement has been made that second-year day students in the Finsbury College are liable to be examined upon subjects brought up in any of the Institution papers. This regulation, of course, may be looked at in two ways. It may be objected that students have quite sufficient to bother their heads about, with lectures and laboratory work, without attending to papers that are often beyond them and devoted to very advanced theory or practice. It is hardly likely, however, that students would be expected to be examined in such subjects as would be then meant. The far more reasonable idea to take is that lectures and text-books, the latter especially, necessarily are somewhat (frequently very much) behind the times. The advantage of having the student's mind directed at once to practical and useful matters in the grand, as well as to experiments and details, cannot be over-estimated. We have had occasion to dwell pretty freely on the subject of text-books and practical knowledge, and are only too glad to see the proper spirit more and more taking its hold on college teaching. For an ardent student we would say: As far as possible, when once the principles are grasped, get to practical applications and the consideration of them. This habit will both render students better budding engineers, and also keep down that remarkable access of conscious knowledge and superiority of students learned in examination matters that is so often manifest in the electrical and indeed in every department of learning. For the student who would succeed practically, really live and work-a-day information is far more likely to prove an incentive to useful work than much study of bound books. Therefore we would tell every student to get as much acquaintance as possible red hot and in paper backs—that is, read the papers, the journals, the "proceedings" of societies, and try to digest as much as he can of what is therein given, remembering, however, as Mr. Sprague has said, not everyone can swallow high mathematics with gusto, or thrive thereon, but realising also that the latest, best, and most practical information is only to be found in books, months, or even years, after it is first published in the technical journals.

CORRESPONDENCE.

MR. KAPP'S CANTOR LECTURES.

To the Editor of the Electrical Engineer.

Sir,—I have to thank Mr. Kapp for his offer to publish the authorised figures of the Barking-road installation.

When my board think it advisable to do so, I should have no difficulty in bringing them before the public. The effort that is being made to prove that five cars cannot operate at the same cost as 300 is quite unnecessary. I would only add that, in response to invitations from various tramway companies and corporations owning tram lines, my company have been and are issuing tenders to electrically equip and maintain tram lines by the overhead, conduit, and accumulator systems.

If electric traction by accumulators were more expensive than horse traction, the North Metropolitan Tramways Company, who have now had something like two years' experience of the work of these cars, would not be, as they are at present, applying to Parliament for powers to extend the system at a capital outlay to themselves of £50,000.—Yours, etc., W. G. M. MACKENZIE, secretary.

March 10, 1891.

THE NATIONAL SPORTING CLUB.

The National Sporting Club, situated in Covent Garden where "Evan's" formerly stood, has Lord Lonsdale for its chairman of committee, with Mr. B. J. Angle, Mr. G. C. Piesse, Mr. J. Hollingshead, Mr. J. L. Shine, Mr. Geo. Edwardes, with other well-known patrons of athletics, to assist him; boxing, cricket, rowing, racing, and all other national sports are included in its programme.

The inaugural opening took place on Thursday week, the 5th inst., when about 2,000 members and their friends were present. The entertainment consisted of boxing in the theatre between amateurs and professionals, with music, supper, etc.

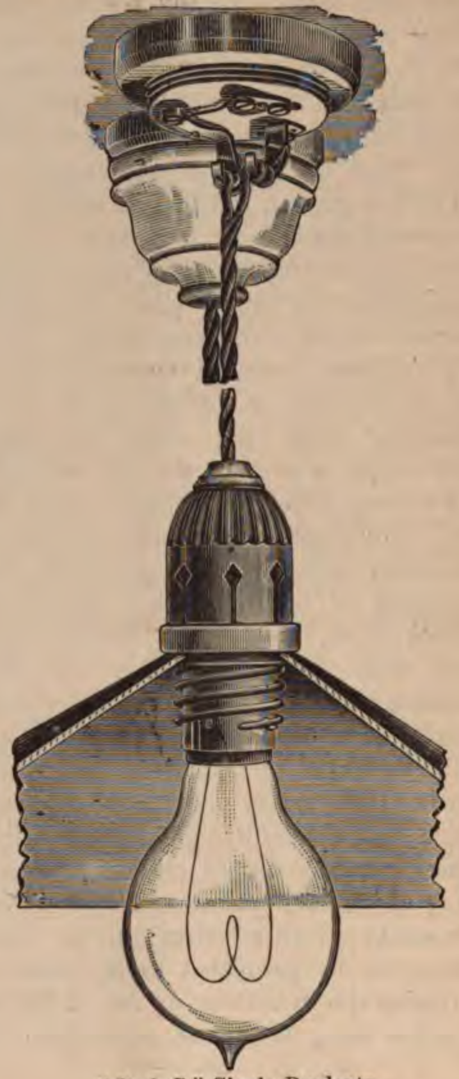
The club is the true ideal of what a sports club should be, and is most comfortably and conveniently fitted with dining-room, smoking-room, and all the other necessities for modern town life, and has a very complete installation of electric light.

This installation has been carried out for the proprietors by Messrs. Henry F. Joel and Co., of 31, Wilson-street, Finsbury, London, in a very short space of time (a little over three weeks), and the whole of the lights have been fitted since the completion of the decorations, without destroying or defacing the building in any way. There are at present about 160 lights, but provision is made for extension to 300 lights. The fittings have been specially designed and adapted to suit the proprietors, and to agree and assimilate with the general design of the building. In the theatre, the fittings are particularly successful; they follow the curves of the arches, lighting up the arena and also the decorated ceiling in a very charming and successful manner, and are much admired. In the conservatory and saloon, the fittings are in accord with the surroundings; in the billiard-room, they give an exceptional light on the tables. Switches are fitted to turn any of the groups of the lights "off" or "on," and all the lights are under control in the porter's box at the entrance. Special switches, with detachable handles, are fitted in the billiard-room. The electric current is supplied from the mains of the Metropolitan Electric Light Co., and when the circuits were recently tested they gave an insulation resistance of over 5,000,000 ohms (more than ten times the required test). All the work has been carried out in accordance with the fire insurance rules. There are some miles of insulated wire laid down, and many thousand feet of casings, all of which are painted with asbestos paint.

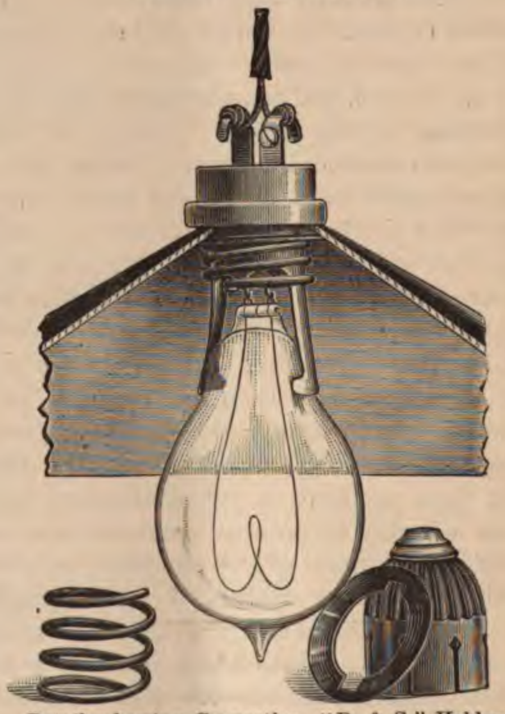
Electric light has now become a necessity for clubs and other such buildings, and in this case it shows off the magnificent suite of rooms and the beautiful theatre in a way that illustrates its beauty and adaptability, while conducing to the purity of the atmosphere, and safety from fire, and the cleanliness of the very handsome decorations that have been adopted.

SUSPENSION PENDANTS.

Now that it is the custom to hang from the suspension wire alone considerable weights in the form of more or less elaborate support for one or more lamps and shades, the advisability of removing the actual pull of the wire from the terminals of the ceiling plate has become more pressing. With this object in view, Messrs. Dorman and Smith, knowing the many failings of the existing kinds of cord grips, have introduced a simple and novel arrangement, which we here illustrate, and which explains itself.



"D. & S." Single Pendants.



Details showing Connection, "D. & S." Holder.

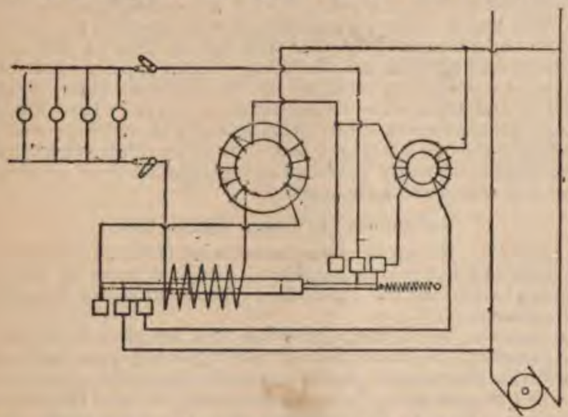
The same principle is also taken advantage of in the two forms of lampholder shown, one being for capped and the other for looped lamps. A peculiar form of shade-carrier will be noticed on these holders, practically a spiral spring nut which cannot be overscrewed, forms a flexible but firm support for the shade, and is easily put on or detached even in the dark.

"THEIR SHADOWS BEFORE."

Electra, Electra, beware of the day
When the pieceworker meets thee to make the job pay,
When the slave of the lathe and the drudge of the file
Does not scruple to scamp and descendeth to guile,
That the oof-bird may come at the end of the week
With abundance of glittering oof in its beak.
Then the prices shall fall, like the brick that is cast
Down the crater of Etna, internally vast.
Like the fall of Satanus from Heaven to Hell,
Like the fall of the clerical faith in Parnell.
Oh! the prices will fall and the standard of work
Will descend to that Hades where "dead horses" lurk,
And the laity's faith in electrical aid
Will decrease as decreaseth the price that is paid,
And the bubble thou blowest will burst in the air—
Electra, Electra, beware, oh, beware! J. H. C. B.

GUTMANN'S SYSTEM OF ALTERNATE CURRENT DISTRIBUTION.

It is a well-known fact that the efficiency of converters varies with the load, and that as the load decreases the efficiency diminishes. This, of course, entails a serious loss of energy, and it therefore becomes highly desirable to introduce a method by which converters may be operated continuously at their best efficiency. This is especially desirable in large installations including a number of converters, where the demand for current is apt to fluctuate between wide limits.



To effect this object, Mr. Ludwig Gutmann, of Pittsburgh, Pa., has devised the arrangement shown diagrammatically in the accompanying illustration. The method consists in keeping one converter permanently in circuit, and automatically introducing more and more converters into circuit as more and more current is drawn from the secondary, and *vice versâ*; and of cutting in, and out, the first converter according whether little or no current, respectively, is required.

This is accomplished by means of a single solenoid and core which operates a simple switch arrangement, by which the proper number of converters are included in the circuit, depending on the load.—*Electrical Engineer* (New York).

CHELSEA.

REPORT OF THE SURVEYOR ON OVERHEAD WIRES AND CABLES, UNDERGROUND PIPES, WIRES, CABLES, ETC.

1. In acccordance with your resolution of the 18th November, 1890, I beg to submit the following report, relative to the pipes, wires, etc., in Chelsea, both overhead and underground.

2. The resolution referred to was as follows: "That the surveyor make a report showing the number of gas and water pipes, and their diameter; cables for electricity, wires overhead and under public roads, their use, and who is responsible for accidents to persons and property through defective pipes, wires laying or fixing, and what tenure they hold."

3. This resolution is sufficiently wide in its scope to justify, were I able to write it, a treatise on the liabilities of all companies using roads. But as the subject is one of very great importance, both to the local authority who repairs the streets and the public which uses them, I propose, after describing the conditions under which the wires, pipes, etc., are laid, to give a general idea of the purposes for which they are used, and, after dealing with the subject as required by the Vestry's resolution, to suggest what appears to me to be the best method of ensuring efficient inspection and supervision, and of guarding against any danger of accidents which may now exist.

4. To the local authority this subject is one of importance, because it finds that it is impossible to maintain roads in fair condition when they are constantly being disturbed by gas, water, and electric light companies, and that the presence of iron boxes, plugs, etc., in both roads and footways necessitates constant attention and repairs around them, as the wood or stone pavement wears more rapidly than the iron. Attention and repairs to roads and pavements mean extra work, and consequently extra cost; and a local authority which is forced to expend public money owing to the regulations of private companies is naturally very jealous of the rights over public roads, which those companies claim, and is justified in demanding that the privileges of private companies shall not clash with the interests of the public, of which they are the guardians.

5. The general public, besides having to suffer annoyance and inconvenience, owing to the roads and pavements being disturbed, are very often in a state of alarm at unknown dangers which are supposed to lurk hidden beneath the roads and footpaths. Reports of accidents, or supposed accidents, from falling wires which decapitate the unwary; stories of electric currents which go astray and give violent shocks to inoffensive pedestrians who step unsuspiciously on iron pavement boxes, do not tend to reassure timid persons, and although such reports are generally grossly exaggerated, and the dangers magnified exceedingly by every alarmist, the public is not aware, or at any rate not convinced, of this.

The Law Respecting the Fixing and Laying of Wires, Pipes, etc.

6. No person can legally lay wires, pipes, etc., under public streets without the special sanction of Parliament, or the authority of a provisional order or license from the Board of Trade. The restrictions imposed by law upon the fixing and laying of wires pipes, etc., are as follows:

7. The Postmaster-General works under special Acts of Parliament. He can, therefore, with the consent of the local authority, fix telegraph poles in streets, and also with their consent lay pipes, etc., under streets. Should the local authority object, the Postmaster can appeal to a magistrate.

8. Until 1878 the local authorities had an absolute veto with regard to the erection of wires along streets, but in that year the right of appeal against the decision of the local authority was given to the Postmaster. He can, however, without the consent of the local authority, fix any wire across a street, provided that it is not an obstruction, dangerous, or a nuisance.

9. *The Telephone Companies.*—While the Postmaster works under special Acts of Parliament, the telephone companies depend upon the general law. They therefore cannot place poles in the roadway or footway, from which to affix their wires; as to erect any permanent obstruction on the highway, without lawful excuse, is an unlawful act, and a nuisance at common law. Neither can they lay their wires underground, as it is an indictable offence to dig trenches in a highway without parliamentary sanction. They therefore are compelled to use overhead wires, fixed to supports on private houses or on private land. But the wires themselves may be fixed across streets.

10. The local authority has no veto upon the erection of a wire across a road, provided that it is suspended from supports not upon the road, and provided that the wire is not dangerous nor an obstruction which interferes with the free use of the road; as the ownership of the road, so far as the local authority is concerned, extends only so far down and up as comprises the area of the ordinary user of the road.

11. An ordinary freeholder has rights between the surface and the sky, and the surface and the centre of the earth, but the Vestry as a local authority has not. Thus, if a gold mine were discovered under the roadway, the Vestry could not work it; but if a wire passes 50ft. above a private individual's back garden, he can object to it. In fact, one of the telephone companies states that a gentleman maintained that a wire stretched across his house obstructed his view of the sun by day and the stars by night, and that solely in consequence of this objection they had to move it.

12. *Private Telephones.*—Any private person can fix a telephone wire across a street without the consent of the local authority, in the same manner as the telephone company can, provided that such wire is not an obstruction, dangerous, or a nuisance.

Electric Light Companies.

13. It is worthy of note that the Electric Lighting Act of 1882 does not expressly mention the right to break up the public roadways as one of the general powers given to electric lighting undertakers, but the power is given them by incorporating the provisions of the Gas Works Clauses Act, 1847, into the Electric Lighting Act. Under that Act and the Acts confirming their provisional orders, the various companies are bound to proceed as follows—viz.:

14. The Chelsea Electricity Supply Company are compelled to

give one month's notice to the Vestry, and to the Postmaster-General, before breaking up any road to lay down mains, and to submit a plan showing the position of the proposed mains. If the Vestry or the Postmaster object to such notice, an appeal can be made to the Board of Trade, and they can authorise the work to proceed should they think fit.

15. The Vestry, however, may if they desire break up the roads, etc., in accordance with the company's requirements, and fill in and reinstate the trenches after them.

16. It is specially provided in the Chelsea Company's Act, that no electric lines shall be placed overground without the express consent of the Vestry.

17. The London Electric Supply Corporation are compelled to give one month's notice to the Postmaster-General, the local authority, and the County Council, before breaking up any road to lay down mains, and to submit a plan of their intended works. If any objection is raised by any of the above authorities, an appeal can be made to the Board of Trade in a similar manner to the last company. The Vestry can also break up and reinstate roadways should they think fit. Overhead wires may not be placed without the express consent of the London County Council, not the Vestry.

18. The Cadogan Electric Light Company have as yet neither Act of Parliament nor provisional order to authorise them ; but the Vestry has granted them permission, so far as they were able, to proceed as though they had obtained a provisional order.

19. Acting on the right which any private person appears to have, within the limits previously stated, they have carried overhead cables across certain streets, and, with the consent of the Vestry, have laid underground mains in various places. They are, however, always liable to have their cables objected to by the owners of the land across which they pass, and it is very doubtful whether any private person who felt himself aggrieved could not restrain them from opening the ground to lay mains past his house.

20. In the Electric Lighting Act, 1888, it was provided that where any electric lines were not enclosed in any building, and were used otherwise than subject to a provisional order, license, or Act, the Board of Trade could, if they saw fit, give notice to the owners of such electric lines requiring them to be used only in accordance with such regulations as the Board of Trade should prescribe. Acting on this provision, the Board of Trade, in August, 1889, served a series of regulations upon the Cadogan Electric Light Company with reference to their overhead wires. These regulations, whilst to a certain extent controlling the use of such electric lines, do not legalise them.

21. The gas company is required to give the Vestry three days' notice in writing of their intention to open the road to lay down pipes (except in cases of emergency), and to submit a plan of the intended works. Should the Vestry refuse their consent, the company may appeal to the Board of Trade.

22. The water works companies are also required to give the Vestry three days' notice in writing before opening ground, and no new mains are to be laid during the months of December, January, and February, without the sanction of the Vestry.

23. It has, however, been found in practice that it is most convenient to require the various companies to give a preliminary notice, and submit a sketch plan before commencing any works, and to submit the detailed plans when the works have been completed, as it is practically impossible, owing to the crowded state of the streets, to compel them to adhere to plans prepared before the ground has been opened.

Overhead Wires.

24. The law relating to overhead wires generally is in a very unsatisfactory state. It is true that, as previously mentioned, the Board of Trade can, if they see fit, serve regulations upon the owners of electric lines, but it is left for the Board of Trade to find out the owners, and there is no obligation in most instances laid upon the person who fixes a wire over a street to let the local authority or the Board of Trade know it is there. The wire may be fixed securely enough at first, and perhaps may be in use for some years, but after that time, for some reason or another, it may drop out of use, and be left suspended over a street until it falls. We have had an instance of this in Chelsea. The Standard Time Company, who keep clocks timed by electricity, bring their wires to Chelsea by the Metropolitan Railway. A wire crosses Sloane-square to The Star and Garter Hotel, to time the clock there. The company also time a clock in College-street. They used to continue the wire across Leete-street to Cadogan-terrace, along Cadogan-street, across Marlborough-road, to Francis-street, and thence to College-street. When the alterations were being made in Leete-street, they disconnected the wire there, and timed the College-street clock from their main wire at South Kensington Station. A wire was thus left useless across Cadogan-street, and I believe broke before it was removed by the company.

25. Private telephones are increasing, and are likely to increase as the telephone patents are expiring. A large public company are likely to have some, more or less efficient, supervision over their wires, but a private person who has a telephone across a public street between his house and his stables, is not likely to think of the wire if he lets his stables.

26. Thus it appears that if a wire is once fixed across a street, it may stay there until it falls, so far as inspection by a competent authority is concerned, unless it appears to be dangerous ; and a wire 40ft. or 50ft. away must be in a very bad state if it looks dangerous.

27. The Board of Trade's regulations as to "aerial conductors" are of course excellent so far as they go, but there does not appear to be any authority to see them properly carried out, as I have lately been informed by the Postmaster-General that the regulation requiring the Cadogan Company to furnish him with a plan of their wires has not yet been complied with. And these regulations are manifestly only for electric light wires.

28. That there should be some efficient supervision is, I think, obvious. Telephone wires will not last for ever, and when they get beyond a certain stage of decay they break and fall. The snowstorm of 1886 reminded us of this fact. It is true that the storm occurring in the night caused an immunity from accidents, and it is also true that the effect of broken wires is generally greatly exaggerated, but still, after allowing for all this, it is not pleasant to think that wires which may cause harm are fixed without adequate supervision.

29. Adequate and constant supervision are undoubtedly necessary. In his evidence before the Select Committee on Telephone and Telegraph Wires, the engineer to the United Telephone Company stated that wires began to decay in from three to seven years, but that in London from five to six years might be taken as a rough average of the life of an iron wire. The engineer to the Lancashire and Cheshire Telephone Company stated that in districts where manufacturing chemists congregated wires did not, in some instances, last more than 12 months.

30. On the other hand, it must not be forgotten that overhead wires are a great public convenience, especially telephone wires ; and it is just the telephone wires which it is most important to have overground. It has been stated by telephone engineers that, owing to the effects of induction in an underground system, the telephonic message sent by that method is apt to become weak and undefined. With a telegraph the difficulty is not nearly so great, as a much more powerful current is used.

31. Apart from the scientific difficulty there is the monetary one. An overhead wire can be fixed at a cost of about £16 per mile, while an underground one will cost £350. If, therefore, telephone companies were compelled to place their wires underground, it would not only mean that the service would be less efficient, but that the cost of using the telephone would be practically prohibitive.

32. Before leaving the subject of overhead wires, I should state that the Post Office use either iron or copper wire, the telephone company iron wire, phosphor-bronze wire, and also hard-drawn copper wire, and in some instances a cable, consisting of copper wire covered with guttapercha, which is suspended by means of iron wire. The Board of Trade's regulations with regard to the Cadogan Electric Light Company are that their cables shall be 30ft. above the street, and 6ft. from any building ; that supports shall be at intervals not exceeding 200ft. where the conductor is in a straight direction, and 150ft. when the direction is curved ; that the conductor shall not cross a street at a less angle than 60deg. with the direction of the line of street ; and that every high-pressure conductor shall be properly insulated and suspended from a wire by means of a non-metallic ligament.

Underground Pipes, Wires, etc.

33. The law relating to underground works is in a more satisfactory condition, but it is impossible to carry out some of the provisions in various Acts of Parliament on account of the narrowness of the streets.

For instance, by the Metropolis Gas Act, all pipes to be laid by a gas company are to be laid at the "greatest practicable distance" from the nearest part of any water-pipe, and wherever the width of the roadway or footpath will allow, at least 4ft. from the water-pipe. Now, in Fulham-road, near Limerston-street, there are three gas-pipes and six water-pipes. The gas-pipes are respectively 9in., 3ft., and 1ft. in diameter, and the water-pipes, 4in., 1ft., 2ft., 1ft., 2ft., and 4in. But as the width of the street is only 40ft., and none of the pipes are in the footway nor the centre of the roadway, they are laid regardless of these provisions.

34. It appears to me that the restrictions which are placed upon persons laying pipes, etc., under highways are not so much owing to the Legislature holding any theory that they are an interference with public property, as to the theory that the opening of the highway to lay pipes will obstruct the public in their right to walk along the street, or that the soil of the street is the property of the adjoining owner, and that the laying of pipes will curtail his right. There are a few ancient corporations, such as Bristol, which claim under old charters that they are the owners of the soil of the streets, but such claims are very exceptional. I believe the City of London make such a claim, but I doubt whether they could enforce it.

35. It is probably owing to this jealous regard for both public and private rights that the Board of Trade are so careful in granting extensions of areas of supply to electric lighting companies. When the Chelsea Electricity Supply Company lately applied for an extension of their area to streets instead of an area, one of the objections raised by the Board of Trade was that if only streets were named, any person whose premises were within a few yards of such streets, but not actually in it, could not be supplied, as the Board of Trade would not sanction the laying of any wires in any part of a street which had not been formally included within the scope of the provisional order.

36. The gas company lay mains of 1¼in., 1½in., 2in., 2½in., 3in., 4in., 5in., 6in., 8in., 9in., 10in., 12in., 14in., 16in., 18in., 20in., 24in., 26in., and 36in. in diameter, and the water company 3in., 4in., 5in., 6in., 7in., 9in., 12in., 18in., and 24in. in diameter. It is the aim of these companies to lay their pipes at from 18in. to 3ft. below the crown of the roadway, but when two pipes cross the gas-pipe is laid over the water-pipes. The Vestry, under their agreement with the gas company, provide that the company shall lay their pipes at not less than 20in. below the roadway.

37. The Chelsea Electricity Supply Company lay their wires on

the Callender-Webber system, in casings of bitumen concrete. The cables are of copper wire, covered with vulcanised bitumen, properly bound with tape.

38. The London Electric Supply Corporation's cables are laid in a cast-iron pipe, 4in. in diameter.

39. The Cadogan Electric Light Company also lay their mains in iron pipes.

40. The electric light companies lay their mains, where possible, between the paving and the crown of the vaults, but when they lay them under roadways, they are about 2ft. 6in. deep.

The Owners of Pipes, Wires, etc.

41. The companies and persons having overhead and underground pipes, wires, cables, etc., in Chelsea, are as follows: The General Post Office, who have overhead wires in various parts of the parish, as shown on the plan submitted, and in the schedule attached to this report. They have also underground pipes containing wires from Sloane-square, through Whitehead's-grove, etc., to Fulham-road, as described in the schedules. The United Telephone Company, who have various overhead wires along King's-road and various other streets. The Standard Time Company, who have wires to time clocks at Sloane-square and College-street.

The private telephones belong to—(*a*) Admiral Sir George Willes, for communication between 73, Cadogan-square and 91, Little Cadogan-place; (*b*) Mr. W. Seymour, for communication between 188, Walton-street and 10, Exeter-place; (*c*) Mr. G. P. Kent, for communication between 11, Whitehead's-grove and 32, Fulham-road; (*d*) Mr. Oswald Craske, for communication between 93, Sydney-street and Montpelier-street, Brompton; (*e*) Sir Arthur Charles, for communication between Garden-corner, Chelsea-embankment and 29, Christchurch-street. All these are overhead wires. The Cadogan Electric Light Company, who have various overhead cables for conveying their electric current; and underground mains along Chelsea-embankment and through Tedworth-square and Smith-street. The Chelsea Electricity Supply Company, who have underground mains throughout the north-east portion of the parish. The London Electric Supply Corporation, who have a main under Pavilion-road. The Chelsea Water Works Company, who have a network of mains throughout the parish. The Gas Light and Coke Company, who also have their mains throughout the parish.

The Use of Pipes and Wires.

42. It is, I think, very well known that ordinary telegraph and telephone wires used for conveying messages are harmless if touched by any person. This, of course, is not the case with some electric light wires. Electric currents are of three kinds—continuous, intermittent, and alternating. A continuous current, when passing through a living body, if it be at fairly low pressure, may be almost imperceptible; the same current, if intermittent, would be uncomfortable; and if alternating, almost insupportable.

43. The strength of current necessary to kill a man varies very considerably, according to circumstances. Happily, accidents of this nature are rare in England, so that electricians have not sufficient data to be dogmatic on the subject. It is required by the Board of Trade that every company supplying a dangerous current of electricity by means of overhead wires, shall properly insulate them by some material approved by the Board of Trade. And every company having an Act of Parliament or provisional order, who are laying their cables under streets, is also bound to properly insulate them. By this means it is impossible for any person to meet with an injury from an electric wire unless through some very exceptional circumstances.

44. The Chelsea Electricity Supply Company use low-tension continuous currents for the supply of their customers. The London Electric Supply Corporation use high-tension alternating currents, and the Cadogan Electric Light Company (I believe) use high-tension continuous currents.

45. The Board of Trade's regulations define: (*a*) A low-pressure supply as a continuous current, not exceeding 300 volts; or an alternating current, not exceeding 150 volts; (*b*) a high-pressure supply as a supply exceeding the limits of low-pressure, and not exceeding a pressure of 3,000 volts, or the equivalent of 3,000 volts, whether the current be continuous or alternating; (*c*) an extra high-pressure supply as exceeding 3,000 volts, or the equivalent of 3,000 volts.

46. The gas and water companies' pipes may be described as of three kinds—service mains, charging mains, and trunk mains. The former supply streets, and, in the case of water mains, are only charged for a short time each day in most parts of Chelsea. The charging mains are to supply a series of service mains, and it is from such mains the water companies deliver water for extinguishing fires, and the trunk mains communicate between the gas works and the storage stations, or one reservoir and another.

Dangers to be Guarded Against.

47. Speaking generally, the dangers to be guarded against are: (1) Injury from overhead wires which fall through decay or insecure fixing. This will be guarded against if the Overhead Wires Bill, introduced by the London County Council this session, becomes law. (2) Injury from high-tension electric wires which are accidentally touched by some person. The Board of Trade's regulations as to safety effectually guard against this, provided that they are properly carried out. (3) Damage caused by fire in consequence of contact between overheated electric wires and some inflammable substance. Danger from this cause is also guarded against by the Board of Trade's regulations. (4) Injury or damage caused to persons or structures by escapes of gas or water from pipes. The danger from gas escapes is more easily guarded against, owing to the escape making itself known by its smell, and to the fact that there is no danger in the gas until a light is brought near it. Damage by the sudden bursting of a high-pressure water main is, of course, almost impossible to guard against, as, directly the pipe bursts, the houses in the vicinity are flooded. It would, however, often lessen the damage from such a cause, if the water companies fixed valves at frequent and regular intervals in their large mains, which could be shut down in cases of emergency.

Liabilities of Companies, etc.

48. The question of the liabilities of companies and others for damages caused in consequence of their works, etc., is, of course, one of the greatest importance. The Gas Works Clauses Act, 1847, gave the companies power to break up streets, to lay pipes, and provided that they should make compensation for all damage caused in the exercise of such powers—viz., breaking up streets; but the Electric Lighting Act of 1882 goes further, and provides that any undertakers under that Act shall make full compensation for damage caused in the exercise of [all] the powers in relation to the execution of works, not the breaking up of streets only.

49. This, however, does not mean that electric light companies are responsible for any and all damage caused by their works, though, on the face of it, it looks so. Before the company would be liable, it would have to be shown that the damage was caused by some wrongful act, or some act not authorised by their statutory powers. Existing decisions seem to show that where a company are authorised by statute to do certain works, they are protected against all the consequences of doing such works, and all works reasonably necessary and incidental thereto, provided that they exercise due care and skill. This, of course, is only just.

50. If, however, it could be proved that they had constructed a defective work, or negligently used any statutory work, they probably would be liable for damages, as it appears to be a principle of law that a negligent use of a statutory work is one way of committing an act unauthorised by the statute, just as the construction of a work of a different nature to those authorised would be.

51. It is probably certain that any gas, water, electric lighting, or telephone company is responsible for any damage which the exercise of reasonable care would have prevented; or for any damage caused by any of their works being out of repair, when they knew or had means of knowing that this was the case.

52. A gas company is bound to keep up such a reasonable inspection of their mains and pipes as to enable them to detect an escape that might lead to an explosion. If an explosion took place after gas had been escaping for several days, which escape could have been discovered by proper inspection, it would be considered as evidence of neglect on the part of the company.

53. As regards the escape from fittings, etc., a case has been decided which shows their liability. A gas company contracted to supply the owner of certain premises with a service pipe from their mains to the meter on his premises. They laid down a defective pipe, and an escape ensued. A workman employed by a gas-fitter, who was doing some work for the owner of the house, took a lighted candle to find out from whence the escape proceeded. An explosion took place, and damage was caused to the premises. The owner of the premises brought an action against the company, and it was held that he was entitled to recover—the gas company having fixed the defective pipe.

54. But if the damage arose from any cause over which the company had no control, which they could not foresee or prevent, they probably would not be liable. For instance, it was held that the owner of an artificial reservoir was not liable for the damage caused by its bursting owing to a very excessive rainfall. The judges held that the damage was caused by natural causes; therefore the owner was not liable.

55. The decision in the case of Blyth *v.* Birmingham Water Works Company seems to show that a water company, having observed the directions of the Act of Parliament in laying down pipes, is not responsible for an escape of water from them not caused by their own negligence. The company had fixed a fire plug which had resisted the frost for 25 years. A frost of unprecedented severity came, which forced out the plug, and the water escaped from the main. Owing to the stopper above the plug being covered with ice and snow, the water forced its way into the plaintiff's cellar, where it did damage. It was held that the company were not liable, since the accident arose from a frost of extraordinary severity, the effects of which the company could not guard against; and, consequently, there was no negligence on their part.

56. As regards the liability of a company for any damages caused by any defect in the roadway around any of their works, it has been held that a company were not liable for the wearing of the road around these works, provided that they are fixed by statutory powers. For instance, a water company was sued for damages caused by a fire plug projecting above the roadway. The Master of the Rolls, in giving judgment, said: "It is said that a person who puts a thing into a highway which becomes a nuisance, is responsible for any injury that may result. To my mind that doctrine applies only to persons acting without authority. . . . The company were compelled to put these plugs into the street. . . They could not mend the road; the only thing they could do would have been to cut down the fire plug. One would think that if the Act of Parliament had intended to put such a liability upon them it would have said so." A gas or water company, however, are responsible for damage caused to roadways and footpaths, etc., by their works, whether accidental or otherwise.

57. This decision casts upon the Vestry the duty of keeping

roads and footways around meter-boxes and other works of companies in a state of repair; and as such boxes are increasing, both with gas, water, and electric light companies, it is rather a serious matter. It is not probable that the Vestry will be liable for any damages caused by an accident, unless they had had notice that the roadway around a particular box, plug, etc., was defective, but it greatly increases the cost of maintaining the pavement.

58. Where an asphalte footway is laid without any iron grating or box in it, it would probably last for 10 or 12 years without repair; but when iron covers are fixed in the pavement, the asphalte around them would probably have to receive attention some four or five years before the rest of the paving would be worn out. The companies are entitled to fix their iron boxes, etc., in roads and footways, and the Vestry cannot very well prevent them; but it is much to be regretted that they are not compelled to fix some description of cover that will wear more evenly with the pavement.

Tenure.

59. As regards the tenure of companies and persons having overhead wires across public streets, it is under the present law quite secure, so long as the wires are not dangerous nor an obstruction, but their tenure across private land is most insecure. Were a majority of property owners to stand out for their legal rights, the placing of these wires would be an impossibility.

60. Where Post Office wires are once laid under streets, they can practically remain there for ever. The same may be said of gas and water pipes, so long as the company continue to supply the public.

61. As regards electric light companies' wires, those laid under parliamentary sanction (which are, in Chelsea, those of the Chelsea Electricity Supply Company and the London Electric Supply Corporation) can be acquired by the Vestry at the end of 42 years from the date of the granting of the provisional order, by compulsory purchase. Should, however, the Vestry not wish to purchase the company's plant at the end of the 42 years, they may have the option of doing so at the end of every subsequent period of 10 years.

62. Section 2 of the Electric Lighting Act of 1888, which contains the purchase clause, is described in the marginal note "Purchase of undertaking by local authority." But all that is purchased by the local authority is the then market value of the lands, buildings, works, materials, and plant, without any addition in respect of compulsory purchase, goodwill, or profits.

63. Any electric wires, etc., placed under streets without parliamentary sanction (such as those of the Cadogan Company) could not be purchased by the Vestry under the purchase clauses, and as the law stands at present can remain in use under the streets until they become a nuisance to any person.

64. The provisional orders granted to either the Chelsea Electricity Supply Company, or the London Electric Supply Corporation, may be revoked by the Board of Trade: (1) If the Vestry as the local authority represent to the Board of Trade that the undertakers are not executing the works or supplying electricity in accordance with the order. In the case of the London Electric Supply Corporation, the London County Council may also make such a representation. (2) If the undertakers represent to the Board of Trade that they cannot carry on the undertaking at a profit. (3) If the Vestry and the undertakers agree that the order should be revoked, and in the case of the London Company, if the Vestry, the London County Council, and the company agree to ask for its revocation.

Lengths of Wires, Pipes, etc.

65. The lengths of lines of wires, etc., in Chelsea is approximately as follows—viz.:

	Chelsea.		Kensal Tn.		Total.	
Overhead Wires and Cables.	M.	YDS.	M.	YDS.	M.	YDS.
General Post Office	4	1,010	—	1,590	5	840
United Telephone Company	7	1,640	—	—	7	1,640
Cadogan Electric Light Company	1	1,580	—	—	1	1,580
Private telephones (including Standard Time Company)	2	255	—	—	2	255
	16	965	0	1,590	17	795

As, however, there are a great many wires on some lines, the total length of wires is about—Post Office, 17 miles; telephone company, 80 miles, private telephones, two miles; total, 99 miles.

	Chelsea.	
Underground cables.	M.	YDS.
Chelsea Electricity Supply Company*	5	300
London Electric Supply Corporation	—	1,070
Cadogan Electric Light Company	—	1,440
	6	1,050
General Post Office	2	180

	Chelsea.		Kensal Tn.		Total.	
Underground pipes.	M.	YDS.	M.	YDS.	M.	YDS.
Gas Light and Coke Company	41	1,535	9	450	51	225
Chelsea Water Works Company	46	1,498	—	—	46	1,498
West Middlesex Water Company	—	—	8	1,590	8	1,590
	88	1,273	18	280	106	1,553

General Observations.

66. The increase of overhead wires and the crowded state of the roadway under the street, has lately very often received the attention of the vestries, the Metropolitan Board of Works, and the London County Council.

In the session 1890, the London County Council brought in a Bill to enable them to regulate overhead wires, and to form subways. By this Bill it was proposed that the London County Council should make and enforce by-laws for the regulation and control of overhead wires, and that they should also be empowered to make and maintain subways, and cause pipes to be placed therein where possible. This Bill, however, was dropped. One of the objections raised by this Vestry to the Bill was, that the enforcement of by-laws was entrusted to the London County Council, and not to the vestries and district boards; the Vestry taking their stand upon the report of the Select Committee on Telephone and Telegraph Wires, who considered the matter in 1885. This committee reported to the effect that by-laws for the regulation of all wires should be made for the whole of London by the Metropolitan Board of Works (subject to the approval of the Board of Trade), and that the enforcement of the by-laws should be entrusted to the vestries and district boards. This session the London County Council are also bringing in a Bill to provide for the control and regulation of overhead wires in the county of London. The Vestry have decided not to oppose it, as it contains a provision that by-laws are to be made by the London County Council, subject to the approval of the Board of Trade, and that the enforcement of such by-laws shall rest with the local authority. If this Bill is carried, the overhead wires of London will at last be put under efficient control.

67. I am of opinion that if these by-laws provide that every person fixing an overhead wire shall give notice to the local authority, so that the position of his wire shall be marked on plans to be kept by them, and in case of alteration or removal of the wires, the same shall be notified to the local authority; and that if the wires are from time to time inspected and removed when disused or defective, not only will the public safety be assured, but the fixing of unauthorised wires will be impossible. This Bill also provides that the local authority may charge every person owning any overhead wire such reasonable fees in respect to the identification of their wires, and such reasonable annual charges in respect of the supervision of such wires as the by-laws shall direct. It also empowers the local authority to appoint an inspector of overhead wires, who, when in uniform, shall be authorised to enter any premises to inspect any wires attached thereto.

68. Should, however, this Bill not be passed, the Vestry could ask the Board of Trade to serve regulations upon the owners of electric wires, under the fourth section of the Electric Lighting Act, 1888, by which means some sort of supervision would be obtained. With regard to the company now supplying electricity in Chelsea through underground mains without either a provisional order or a special Act, it seems to me advisable for the Vestry to take steps to have the interests of the public safeguarded in the same manner as with the two other companies. Both these other companies have been served by the Board of Trade with a series of regulations for ensuring the safety of the public, and it seems only right that the same regulations should be served upon the Cadogan Company. By the fourth section of the Act of 1888, it is enacted that where any electric lines are laid down, or erected in, over, along, or under any street, the Board of Trade may, if they think fit, serve a notice upon the person using such electric line, requiring them to use such line only in accordance with such regulations for the safety of the public as the Board of Trade may prescribe. It is thus quite competent for the Board of Trade to serve the necessary regulations upon the Cadogan Company, and thus put all three companies in Chelsea under the same supervision.

69. As regards the Post Office, gas, and water mains, I consider that it would be a great advantage were they required, the same as the electric light company, to once every year correct the maps showing the positions of all their mains, pipes, etc., and to submit a copy of the same to the Vestry, so that there would always be a correct record of all underground works kept at the office. Though I am bound to state that the Vestry's officers always are courteously granted every facility to enable them to inspect the records kept by the different companies at their offices.

70. In conclusion, I would suggest to the Vestry the desirability of—1. Petitioning in favour of the London Overhead Wires Bill, which has been submitted to Parliament by the London County Council. 2. Requesting the Board of Trade to see that their regulations as to aerial conductors served upon the Cadogan Electric Light Company, are complied with. 3. Requiring the Standard Time Company to remove that portion of their overhead wire between Cadogan-street and College-street which is not in actual use. 4. Requesting the Board of Trade to serve regulations for ensuring safety of the public upon the Cadogan Electric Supply Company, similar to those served upon the Chelsea Electricity Supply Company and the London Electric Supply Corporation.

71. The schedules following this report are: (*a*) Overhead telegraph wires. (*b*) Overhead telephone wires belonging to the United Telephone Company. (*c*) Overhead telephone wires belonging to various persons. (*d*) Overhead wires belonging to the Standard Time Company. (*e*) Overhead cables belonging to the Cadogan Electric Light Company. (*f*) Underground telegraph wires, laid in iron pipes. (*g*) Fire alarms. (*h*) Chelsea Electricity Supply Company's underground cables. (*i*) London Electric Supply Corporation's underground cables. (*j*) Cadogan Electric Light Company's underground cables. (*k*) Gas-pipes belonging to the Gas Light and Coke Company. (*l*) Water-pipes belonging to the Chelsea Water Works Company and the West Middlesex Water Works Company.

T. W. E. Higgens, A.M.I.C.E.

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* The Chelsea Electricity Supply Company have about 25 miles of cables laid in Chelsea.

TRANSFORMER DISTRIBUTION.*

BY J. SWINBURNE, MEMBER.

(*Concluded from page 246.*)

In discussing such questions, however, we must always remember that the size of the machine is most important. A small dynamo has high resistance, small cross-induction, and small armature reaction. A large machine has a small resistance and great armature reaction. Large machines may therefore easily run well in parallel or as motors, without automatically varied field excitations. A very small lagging current will reduce the field of a large machine 3 or 4 per cent., and the extra loss of power in the armature is small; for if C is the component of the current that is in step and c the lagging component, the power wasted in the armature is not $r\,(C+c)^2$, but $r\,C^2+r\,c^2$—a very different matter.

The case of motors, however, is not the same. A two-horse or one-horse motor is about the size that is most needed. There is no opening for 100-kilowatt motors on supply circuits just now. In these small sizes c will be very large compared with C, so automatic regulation of the field may be of the highest consequence.

The subject of motors is of enormous importance, and is most interesting. I fear it cannot be pursued here for want of time. It is to be hoped one of my hearers may be induced to write a paper on this subject at an early date, unless, as is probable, it is exhausted in Mr. Kapp's Cantor Lectures.

According to the armature reaction theory, then, whether a machine will run in parallel with others depends on its armature resistance and armature reactions. It must be borne in mind that most machines have cast-iron fields, and though that may make no difference according to the orthodox theory, it does from the armature reaction point of view. If the field magnets do not quickly respond to the armature reactions, it may be difficult or impossible to run machines in parallel.

Another important consideration is the government of the engines. If two engines are working two machines in parallel at 200 revolutions, and one governor is set for 200 and the other for 195 revolutions—if the governors are truly isochronous, one engine and dynamo will supply the whole of the power, and the other will be dragged round idle. The whole question of the government of central stations requires the most careful consideration. I have dealt with the matter at some length elsewhere,† but the subject should be very fully thought out in designing stations.

ARRANGEMENT OF STATION.

Whatever system of distribution be used outside the station, the power leaves by high-pressure leads. In this country 2,000 volts is the pressure commonly employed; in America 1,000. I cannot help thinking that the Americans are right. The use of 2,000 volts does not decrease the cost of copper so very much, and it increases the cost of insulation enormously. In addition to this it increases the dangers of breakdowns, and the chance of danger to life; 2,000 volts seems to have been chosen in the early days, when people had very little idea of the commercial difficulties of high-pressure insulations. In addition to this high pressure increases the cost of transformers as well as dynamos, and also lessens the output for a given size.

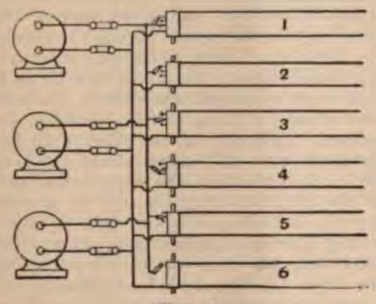

FIG. 8.

If the machines are employed in parallel, they may feed into common bars, as in the case of direct currents. If each district must have its own circuit—which seems to be generally assumed necessary—each circuit may be led away from the common bars with a transformer regulator in it. One objection that has been raised against parallel working is that, if each district has its own system, it may have an earth on one lead without disaster, while, if the station is in parallel, two leaks in the whole system cause a breakdown. This objection comes from America, where they have had a great deal of experience, but it seems to assume the leads to be in a very bad state. There is no need for such danger, however, for each district may be fed through a transformer, so that it has no metallic connection with the system of any other district. It is most difficult to understand why central station machines are made to give high pressures to begin with. In most forms of dynamos 2,000-volt insulation adds very materially to the cost of the machine, and lessens the output for a given size in addition. The difference of cost would more than cover the extra cost of transformers, as large converters can be made for considerably under £1 per 1,000 watts; and the efficiency, when very large, is very high, being above 99 per cent. at full load. So that the efficiency of a low-pressure dynamo and transformer is higher than that of a high-pressure dynamo working direct. It is also a great advantage to have all the switches, connections, and measuring instruments on the low-pressure side. The high-pressure circuits may then be arranged to have no metal exposed anywhere. If each district must have its separate circuit, it has its own step-up transformer, with its regulator. If feeders are used on any system, each feeder has its step-up transformer, which is made adjustable; or it may have an adjustable transformer and a feeder regulator such as that designed by Mr. Kapp. If the district is large, it may have large transformers. Several feeders may then come off in parallel, each feeder having its own regulator. The regulators may have the adjustable parts connected with the low-pressure supply, so as to avoid high-pressure switches or other gear.

One arrangement is shown in Fig. 8. The dynamos are all in parallel, and wound for 100 volts, the immediate neighbourhood of the station being fed direct. Each feeder circuit has a transformer with a variable number of primary turns. A compensated voltmeter is placed on each, and all the attendant has to do is to alter the switches a little occasionally, so as to keep all the instruments' pointers vertical.

TRANSFORMERS.

It is not my intention to go into the question of leads, as I am informed that a paper specially devoted to that important subject is to be read here very shortly; I am therefore most happy to leave the very special question of high-pressure alternate-current mains in far abler hands.

Before discussing the relative merits of house transformers, low pressure direct from the station, and various sub-station arrangements for distribution, it will be best to consider the vexed question of the transformers themselves.

In 1884 electrical engineers were surprised to learn from Dr. Hopkinson that the Gaulard and Gibbs transformers gave something like 90 per cent. full-load efficiency. Since then alternating work has developed enormously; but a complete change has come over the transformers: they are almost always made with the iron circuit closed on itself. The closed iron circuit has been regarded as an enormous advance on the old form; but it is difficult to find any definite statement as to where the advantage comes in. It was for a long time assumed that almost any closed-circuit transformer would give an efficiency of something like 98 per cent.—in fact, that the loss in transformers might be neglected.

In a discussion on the relative merits of direct and alternate current distribution, Mr. Crompton said that the efficiency of the ordinary commercial transformer in a station was about 50 per cent.; and I need hardly say he was not believed. He laid particular stress on the small proportion of the total number of lamps installed really used. The loss in the iron in transformers has till lately been very much overlooked; if it is even a small percentage of the full load of the transformer, it mounts up very seriously in station work when the transformers are in circuit all day and all night.

I had the honour of reading a paper before the British Association in 1889, in which the question of design for all-day loads was, as far as I know, discussed fully for the first time; and the relative proportions of iron and copper for closed-circuit transformers which gave the best results were given. At the same time I pointed out that the loss in iron was really such a serious matter that by a special design not only can a very much higher efficiency be obtained at light loads, but that even at full load a new form is better in every way.

The principle of the "Hedgehog" transformer is this: By using an open circuit the iron can be reduced in volume with a given induction. The mean length of the iron part of the magnetic circuit is considerably less, and more copper turns can be wound on without increasing this length much. The additional turns admit of a smaller cross-section of core, so that the iron is enormously reduced. The loss in copper is somewhat increased; but as the loss in copper is only serious at full load, this does not matter.

The old Gaulard and Gibbs form of transformer has the disadvantage of requiring a very large exciting current. Increased number of turns of copper reduces the exciting current; but, in addition, the ends of the core are spread out in a peculiar way, which again reduces the exciting current. The result is that the exciting current, though larger than in the case of closed-circuit transformers, is not a serious matter. The loss in copper is considerably smaller than the loss in iron in most closed-circuit transformers, and, as it varies as the square of the current, it is inappreciable except at full load, which very seldom occurs. The loss in iron is very small, so that the loss per day in ordinary working is very much smaller than in the case of closed-circuit transformers. Since my paper at the British Association, many makers have altered the proportion of their transformers considerably; but still it is impossible to get as good results with closed circuits.

Perhaps the best way I can make this clear is by a comparison of actual transformers. I am here confronted by a difficulty. If I select any particular closed-circuit transformer of a particular maker, all the other makers of closed-circuit transformers would say that I had chosen a bad example; while the maker himself would say that it was an old form, or that he now uses a quality of iron which wastes no power by hysteresis.

A great deal of unnecessary mystery has been made about the efficiency of transformers, and all sorts of roundabout ways of measuring or calculating it have been proposed, and sometimes tried. The matter is simple, however. The loss in the copper can be calculated if the resistance and current are known. The loss in iron in a given type of transformer depends on the quality of the sample used just as much as the loss in the copper depends on the quality of the copper used. I will therefore assume the ordinary "96 per cent." quality of copper, and I will assume that the iron is as good as the soft iron tested by Prof. Ewing. I have the best reasons for knowing that the iron used is generally much below this standard, so this assumption is considerably in favour of the closed circuits. Moreover, I am giving away the loss by Foucault currents, which is often considerable. Of course, anyone is at liberty to assume that he has some particularly good iron; but in discussing the relative value of the two types of transformer, he must allow me the same quality of iron. In fact, I might assume a special quality of copper equally unknown to the trade in mine.

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* Paper read before the Institution of Electrical Engineers.

† *Industries*, September, 1890.

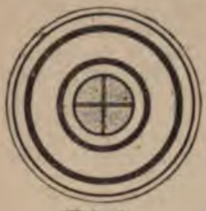

Fig. 9.

As an average size of transformer, one taking 2,000 volts and a frequency of 100, and giving 15 amperes at 100 volts, may be taken, and the working compared.

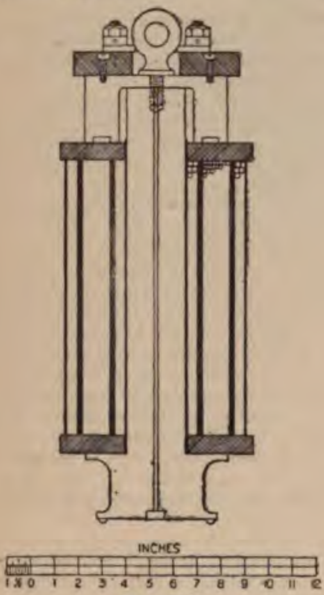

Fig. 10.

Though the theory of the "Hedgehog" transformer was fully discussed in the British Association paper referred, it may not be out of place to describe the construction of the commercial article.

A gunmetal casting forms the backbone of the transformer. It is cross shape in section, and at one end is spread out to form four legs. It also supports the lower flange, or cheek, of the winding. The four spaces have bundles of soft iron wire put in, so that the core is practically cylindrical. The cross-shaped core has been criticised on the ground that there are Foucault currents in it. The least consideration will show that there is no change of induction in it, and therefore no Foucault currents. The iron wire is bound tightly, and the two flanges are slipped into place. A gunmetal "spider" is then screwed to the top. It is finally held on by the eyebelt, but temporarily a set screw is used. The core is then wound in a special lathe in the usual way. Both the terminal board and the coil flanges gave us a great deal of trouble till we found suitable materials. There is a great need of good insulating materials that will not warp, that will insulate perfectly, and that can be worked.

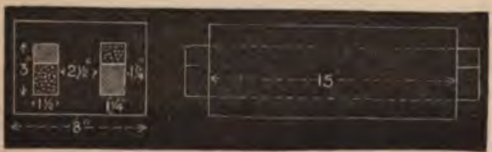

Fig. 11.

The electrical particulars of a 50 8-c.p. lamp transformer are as follows: Core, 13·5in. long, 2·5in. diameter. In taking the area of the core, allowance must be made for the space occupied by the backbone, and for the loss of room in using round wires. Maximum induction, 4,800. Loss of power in iron, assuming it to be of good quality, 13·5 watts. Primary, 3,920 turns of copper wire, 0·042in. diameter; resistance, 37 ohms (warm). Secondary, 200 turns, 19/0·042in.; resistance, 0·098 ohm. Loss of power in primary at full load, due to the transformed current, 21 watts; loss due to the exciting current—0·3 ampere—which is always on, 3·6 watts; loss in secondary at full load, 22 watts. Efficiency at full load, 96·15. This transformer is shown to scale in Figs. 9 and 10.

Fig. 11 is a scale drawing of a closed-circuit transformer I have taken as representative. The primary is 400 turns of 0·042in. wire, and the secondary 20 turns of 0·176in. The loss in copper at full load is 11·3 watts, and the loss in the iron 120 watts. At full load the efficiency is 91·95, or nearly 92 per cent. The diagram, Fig. 12, shows the percentage loss at various loads of the two transformers. The ordinates are percentage loss, and the abscissæ fractions of full load. Curve II. is the "Hedgehog," and IV. is the closed circuit. It will be noticed that the "Hedgehog's" efficiency increases slightly at first, and keeps above 95 per cent. till the load is reduced to one-fifth, and above 90 down to one-tenth load, and it then begins to fall more rapidly. The efficiency of the closed form, however, begins to fall at once, and falls rapidly. In housework the full load efficiency is a matter of little or no consequence. The loss at very light loads is really important. A house that has a 50-light transformer is wired for 50 lamps, and that is the maximum load. As a rule, there are seldom more than 25 lamps on at any one time, and these are on during the evening only. The average load varies with the time of year, and with the class of house. Shops, for instance, have full load for a short time each day. Private houses have the lights in the hall and passages on the whole evening, with either the dining or drawing room, and for some time both the dining and drawing rooms are on. It will be a fair average if we take four hours of half-load per day as the output of house transformers. This means an efficiency of 83·3 per cent. for the "Hedgehog," and only 51 per cent. for the closed circuit. In other, the waste in the closed circuit is between five and six times as great as in the open circuit.

It will, I have no doubt, be urged that various published tests have shown closed-circuit transformers to have efficiencies of, say, 95 per cent. I have elsewhere* examined some of these tests, and shown that, according to the figures given, the results can only be accounted for by the iron acting as freezing mixture, and supplying power to the transformer; the total loss given being in some cases less than the loss by copper resistance. In some other cases too few data are given, so that it is impossible to say how the figures are obtained. In order that an efficiency test can be taken as reliable it must contain full particulars of the transformer. It is then possible to see whether the supposed efficiency of 95 per cent. is due to the type of transformer, to inaccuracies in the measurements, or to phenomenal iron. Of course it is not impossible someone may discover phenomenal iron which will be the salvation of closed-circuit transformers, but it will have to be very good. In Fig. 12, Curve III. represents the loss in a closed-circuit transformer with phenomenal iron having a loss of only 60 watts, or half that taken in the example. The dotted curve, I., belongs to the open-circuit transformer with the same quality of iron; for, of course, the phenomenal iron is available for both. It will be seen that the ratio of the percentage losses is sensibly the same, so that the open-circuit transformer is improved nearly as much as the closed. In the case taken of half-load for four hours a day, the loss in the closed circuit comes out more than four times that in the open, even without redesigning the "Hedgehog." There is thus no chance of iron being found good enough to allow the closed-circuit form to compete with the open. There is one objection to the "Hedgehog" which must not be passed over, and that is the exciting current. The exciting current in the 50-lighter is 0·31; in the closed circuit it is 0·2, so that it is quite half as much again. Moreover, if a better quality of iron is discovered, it will lessen the exciting current in the closed circuit, but will make no perceptible difference in the open, unless it is redesigned. The exciting current does harm in two ways: it weakens the field of the dynamos at the central stations, and it gives rise to troubles in the station at light loads. For instance, if a station had 10 dynamos to run the full load, in the daytime three would be

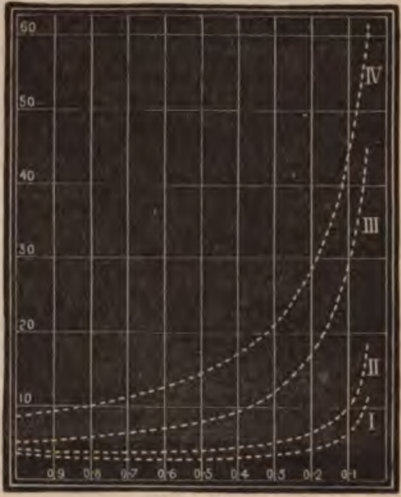

Fig. 12.

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* "Induction, and other Things," *Electrical Review*, October, 1889.

required to supply the exciting current, while in the closed circuit two would do. If the dynamos are direct-driven, this means three engines running light instead of two, and engines running light are very wasteful. These difficulties are, however, to a large extent imaginary. The weakening of the fields is, in ordinary working, counteracted by stronger excitation. Running three dynamos instead of two or one does not involve running three engines: the engine should be uncoupled and the dynamos run as idle motors, supplying the exciting current necessary for the transformers. In the future, it is to be hoped that alternate motors will be used; and as they will be used chiefly during the times the load on the transformers is light, they will thus supply the exciting currents, and it will be unnecessary to run any idle dynamos. It must be remembered that the difference is only one of degree. Closed-circuit transformers have very considerable exciting currents; but it is most desirable to avoid any troubles, whichever kind is used. The solution of the difficulty lies in the employment of condensers. A condenser supplies the exciting current, so that the station dynamos supply a current sensibly proportional to the power used. Thus, in the daytime, with open-circuit transformers, a very small engine and dynamo will give all that is needed. More will be said about condensers presently.

DISTRIBUTION.

Even with the most efficient transformers, the house system is a very poor method of distribution. Apart from the question of loss of power, consider the outlay involved in providing each consumer with a high-pressure double-pole fuse, a transformer, an automatic device for rendering the whole arrangement safe in case of insulation giving way, perhaps a double-pole main switch, a meter, and a fire-proof safe in which all these things have to be enclosed. In addition to this, it involves a complete high-pressure parallel system of distribution, and a network of 2,000-volt underground mains, involving a heavy outlay, and probably heavy depreciation. The adoption of sub-stations is generally regarded as the cure for all this. I believe no sub-station distribution is in use, or even in construction, in this country. The London Electric Supply Company are using sub-stations, but not in this way. These sub-stations merely transform from 10,000 to 2,500 volts, and the distribution itself is carried out by means of house transformers. The principle of sub-stations is that the town has a network of low-pressure mains, with low-pressure feeders led to sub-stations. In each sub-station there are attendants who regulate the pressure in the network, as they have control of the feeders. The sub-station is supplied by high-pressure mains from the station, the power being transformed to low pressure at the sub-stations. There is, however, no need for sub-stations; the low-pressure network may be fed at various points by transformers and feeders coming direct from the station. These transformers need not be in houses or cellars; they can be placed conveniently in the ground in cases filled with insulating oil. The method of feeding into a low-pressure network was described in Mr. Kapp's paper on transformers in 1888, and he referred to it as being in use on the Continent and in America. At the station each feeder can be regulated, and has a compound-wound voltmeter, so that an attendant can keep the pressure in the whole town constant. As Mr. Kapp pointed out, the advantage of such a system is enormous. In direct currents the low-pressure mains must be large. The great size needed for parallel distribution was pointed out at the time of the Electric Light Act of 1882, and Prof. Forbes afterwards went into the matter much more fully; but even now the enormous saving that can be effected by using small low-pressure mains fed at frequent intervals seems hardly to be realised.

In beginning in a new district it may be objected that the subscribers at first are so few that it does not pay to put down low-pressure mains. This would be true if alternate low-pressure had to be as large as direct-current mains. Without going into the cost of a particular case, it is probable that low-pressure mains, large enough to supply any demand likely to arise for many years, can be put down for little, if any, more than the high-pressure network with its expensive insulation. Even in scattered districts it would generally pay to use small low-pressure mains and feeders. The alternate system has so many advantages over the direct in the matters of regulation and distribution, when worked on the low-pressure system, that it is astonishing that such arrangements are not utilised. For instance, with direct currents, it is most difficult to find a leak; and one leak on the positive at the west end, combined with one leak on the negative at the east, will cause serious trouble. With alternate currents, a number of small local networks may be used, each of them being complete in itself. It is not in metallic connection with any other part of the town, nor with the central station. Where it meets the network of the neighbouring district it is not metallically joined, as in the case of direct currents, but is connected through a one-to-one transformer sunk in the ground, in a case full of oil.

After the clear and able manner in which Mr. Kapp urged the advantages of low-pressure networks for alternating currents, it is most astonishing that engineers should go on with house transformers. With the low-pressure network system we have everything that can be wanted. Perfect regulation at every point throughout the town, small mains, inexpensive insulation, cheap and efficient plant, and—what is of importance in comparison with battery work—simple and inexpensive switchboards. There is no trouble from general ground leak: and both arcs and incandescent lighting can be done from the same leads. The only thing wanting is storage; and to what extent is that really necessary, and what does it cost? It is significant that throughout America, where direct-current stations could have it for the asking, it is never used.

At present, however, we are using alternating currents in just about the worst way that could be possibly devised.

CONDENSERS.

Condensers frequently figure in electric light literature, but they are only put forward as possible means for transforming currents. Direct currents and interruptors are generally discussed. Condensers, may, however, have another very large opening in connection with ordinary alternate-current distribution. Take, for instance, the case of arc lamps. It is customary, whenever possible, to run arc lamps in long series with high pressures, generally with direct currents. In many cases such an arrangement is very convenient; but wherever there are incandescent lamps to be fed at the same places as the arcs, it is, of course wasteful to run two sets of engines, dynamos, and leads. With direct currents this is sometimes necessary, for arc lamps in parallel do not burn well on 100-volt circuits, and must be used two at a time; and at 50 volts resistance is needed in series, which is wasteful. With alternate currents nothing is easier than to run lamps with choking coils. If the supply is high-pressure, each lamp can have its own transformer, and the transformer can be wound for nearly constant secondary current. Prof. E. Thomson has brought ont several forms of constant-current transformer, and so has Mr. Tesla. The "Hedgehog" form, however, lends itself especially well; all that is necessary is winding the coils one at each end instead of one over the other. Whether the mains are high or low pressure, choking coils or constant-current transformers will give rise to large currents at the station, which will lower the output of the machines.

For instance, suppose a station supplies a 100-volt secondary circuit by means of transformers with 2,000 volts primary pressure; and suppose there are 200 arc lamps, each taking 33 volts and 10 amperes, arranged on the 100-volt circuit, with a choking coil in series with each. Suppose, for simplicity, that there are no incandescent lamps in use. The arc lamps then take 2,000 amperes and 100 volts; but this does not amount to more than 66,000 watts, as the current is not in step with the E.M.F. The dynamos thus have to supply 2,000 volts and 100 amperes; whereas the same power, if the current did not lag, would be supplied by 2,000 volts and 33 amperes. This gives rise to several troubles. Suppose each machine has an armature wound to give 2,000 volts and 33 amperes, or 66,000 watts, it takes three instead of one to work the lamps. In addition to this, the lagging of the current weakens the field of the dynamos, so that they need more excitation to give 2,000 volts than they would need even on full load on a non-inductive resistance. Moreover, running three engines and dynamos at a third load instead of one at full load is not economical. A condenser takes a current which leads relatively to the pressure, so that it counteracts the effect of the lagging current. The 100 amperes may be regarded as compounded of 33 amperes in step with the pressure, and 95 amperes lagging a quarter of a period. A condenser of about 85 microfarads will supply the 95-ampere component, while one dynamo supplies the 33 amperes really needed by the lamps. This reasoning holds good without the curves of sines assumption.

The use of condensers to overcome troubles arising from exciting or magnetising currents of closed or open circuit transformers has already been mentioned.

They may also be used to increase the output of dynamos. As already explained, even if a dynamo is worked on resistance, the cross-induction causes the current to lag, and the back induction weakens the field. If a condenser is put in shunt to the terminals of the machine, its current strengthens the field again and increases the terminal pressure, and therefore the output. If the condenser is large enough, and if the armature actions are great enough, it might be possible to make a machine excite itself without any field winding at all. This action of a condenser on a dynamo may be equally easily explained on the self-induction theory. The difference between the two theories may be shown here, however. According to the self-induction theory, if the condenser is large enough to produce resonance—that is to say, when $(2 \pi n)^2 \mathrm{L K} = 1$—the output increases till the current is as great as if the no-load pressure of the machine were short-circuited on the armature resistance. According to the armature reaction theory, the machine increases its field till the field magnets become more saturated; in fact, the machine is like a direct-current shunt-wound dynamo which has a low resistance shunt. I do not wish to go into this matter further here, for it might lead to a discussion of a rise in the Deptford mains—a subject, which will be treated, I am informed, in a forthcoming paper, and will certainly receive full justice at the hands of the authors.

The commercial manufacture of high-pressure condensers is not so easy as might be supposed. Knowing the difficulties there are in insulating leads and mains—in which thick insulation is permissible, and, in fact, advisable—it may be realised that to insulate many hundreds of square feet of metallic surface with the thinnest possible material is anything but an easy problem. In addition to being a good insulator, the dielectric must be free from "absorption" Some account of my work on condensers has lately been given.[*] Mr. W. F. Bourne, who has carried out all the experiments, has tried almost every conceivable kind of dielectric, and finds a kind of paper called "butter skin," soaked in paraffin oil, the best material. It is curious that this particular kind of paper is specially made so as to be grease-proof. Some kinds of bank post paper worked nearly as well, but it is too expensive for commercial use. It seems as if the paper must be relied upon for insulation, not the paraffin. The condensers are simple cast-iron boxes containing numbers of sheets of paper and tinfoil. Lids are fitted on and made tight.

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[*] *Phil. Mag.*, February, 1891.

TOWN LIGHTING.

Alternate arc lamps have already been discussed to some extent. In some places, especially in small towns, it is usual to have special circuits for the town lighting, which are shut off during the day. It is needless to point out that if the low-pressure network is used, condensers at the station allow arc lamps to be run with choking coils, and incandescent lamps can be run direct, and it is no more necessary to run special mains for the street lighting than it is needful to put down two sets of gas pipes in a town. Sometimes, however, high-pressure mains are used. Each arc lamp can then have its own constant-current transformer. If incandescent lamps are used, the plan generally adopted is using a transformer for every 10 or 20 lamps. If the wires are underground, this involves great expense, and if overhead it means both expense and unsightliness. A small "Hedgehog" transformer has been designed to meet this particular want. It is so small that it can be worked into the design of the lampholder or shade, and one can be used for each lamp.

In America alternating arc lamps are run in series, with a series transformer for each. This arrangement is quite unnecessary for places where there is incandescent lighting too. It has the advantage of allowing series arcs without bringing high pressures into the lamps. It has no other advantage over direct series lighting. The dynamo used by the Westinghouse Company is made to give nearly constant current. This is a barbarous arrangement. It is a reversion to the old alternating machines of 10 years ago, which gave approximately constant current. All that is needed is great armature reaction, and hence a large machine for the output. The economical way of getting constant current is to use a good dynamo, and to take the governor off the engine, or to use it as a safeguard against racing only. If the Westinghouse machine has only quarter load on, it still goes at full speed, using nearly full steam, and wearing everything out. With a constant-pressure dynamo it would run at quarter speed, each cylinderful of steam being used economically and being expanded properly. To put a constant-speed governor on the engine, and then to design a special dynamo to get over the difficulties you have introduced, is a very common proceeding with direct-current arcs also.

Alternating constant currents have, however, one advantage over direct that I think is not realised. Synchronising motors will run perfectly on series constant-current circuits; and as they run at constant speed, there is no racing or trouble about governing, as in the case of direct currents. Of course, constant speed of engine is here necessary to give constant frequency. Many people seem to have gathered from Dr. Hopkinson's paper that series alternating motors will not run; but this is a false inference.

DISCUSSION—*Authorised Abstract.*

Before the commencement of the discussion **Mr. Swinburne** showed three of his Hedgehog transformers, having outputs of 2,500, 3,000, and 120 watts respectively. The primary of the first was wound for a pressure of 1,000 volts at a frequency of 130, that of the second for 2,400 volts at 70 periods. The third was intended for street lighting. He said he anticipated a lively discussion on the subject of open *v.* closed-circuit transformers, and in order that a better comparison might be made, he hoped speakers would give all details of the patterns to which they referred. As a word of warning to those who intended to criticise the "Hedgehog," he remarked that, like the Scotch thistle, its motto was *Nemo me impune lacessit.*

Mr. Esson said the paper would be regarded as a most important one, for it serves to rectify certain errors which have recently crept into the consideration of alternating-current machines. The discussion on Mr. Mordey's paper left things in a very unsatisfactory state, for no figures were given by which the offered explanation of the experiments could be confirmed or confuted, and at the close of the discussion the author himself admitted that some self-induction was necessary for successful parallel working. The question of how much was needed was not at all clearly understood, for Mr. Swinburne said that coreless armatures had not sufficient, and Mr. Mordey thought that because his armature had no iron core it had practically no self-induction. Now it is known that both were wrong, and that armatures without iron may have self-inductions quite comparable with those of cored armatures. He then pointed out that the classification of armatures into those having iron cores and those without, had led to misconception, and showed that the chief differences between, say, a Siemens or Ferranti alternator and those of the Lowrie-Parker or Westinghouse form, are—first, in the position of the air gap, and second, that in the cored armatures, part of the iron forming the magnetic circuit moves, or is utilised to lay the generating coils on. Figs. 13 and 14 were shown to illustrate these differences. Speaking of Mr. Swinburne's armature reaction theory, he said Dr. Hopkinson included armature reactions in his term "self-induction," and remarked that it would be difficult to deal with self-induction as exhibited by alternators without including these reactions. Dr. Hopkinson had also stated what should be the value of this self-induction; Mr. Swinburne, however, objects to the treatment, on the ground that the harmonic law does not hold, yet he gives no hint as to how the magnitude of the reaction effect is to be estimated, nor any indication of a law that does hold. With the author's objections to complicated high-pressure networks he heartily agreed, having himself made similar observations in the discussion on Mr. Crompton's paper three years ago. He also believed it better to use 1,000 volts instead of 2,000, but failed to see any advantage in feeding parallel machines into common bars, and then isolating the supply circuits by feeding them through transformers. On the subject of transformers he remarked that the true efficiency was the ratio of the useful energy supplied by the secondary during lighting hours to that put into the primary in the 24 hours, and that upon this ratio the efficiency of the system mainly depends. Coming to the examination of Mr. Swinburne's figures for the efficiency of the closed-circuit type, he found this efficiency rather understated. Taking a 50-lighter tested by Prof. Ayrton some three years ago, its efficiency at half-load was 90 per cent., whilst the loss with open secondary was 53 watts. Now, supposing this to work at half-load for only four hours out of the 24, its all-day efficiency comes out 69 per cent., whereas Mr. Swinburne makes out the efficiency of a modern closed-circuit transformer to be only 51 per cent. He thought all would agree that it is of great importance to make the all-day efficiency as high as possible, but doubted whether Mr. Swinburne takes the best way of doing this. For if the Hedgehog transformer be cut in two and made into a closed circuit one resembling diagram 3, the watts spent in hysteresis would not increase by more than 66 per cent.; and if the loss in the Hedgehog is only 13·5 per cent., the 66 per cent. increase would give 22·5 for the loss in the closed-circuit transformer, instead of 120 as given in the paper. Making this correction, the "all-day efficiency" of the closed-circuit converter comes up to 80 per cent., and by redesigning it this could be further increased. It therefore appears that there is little to choose between them. In conclusion, he pointed out that, in 1885, Messrs. Gaulard and Gibbs, at his suggestion, closed the magnetic circuits of their transformers, thus making them resemble Fig. 15. Messrs. Ganz and Co. experimented on a similar form in 1884, and after trying several types have again returned to it, thus showing that no great advance has been made on the shape he suggested some six years ago.

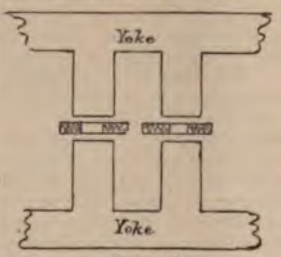


FIG. 13.

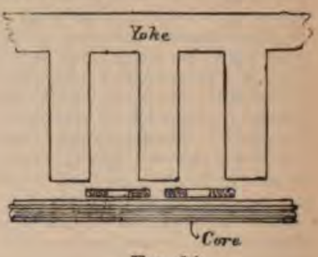


FIG. 14.

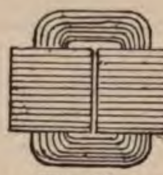


FIG. 15.

Mr. Mordey said he did not propose to touch upon the first part of the paper, as he thought he could best utilise the time at his disposal by confining himself to one definite subject. On alternators, he did not at present wish to add anything to the practical contribution that, two years ago, he had given to the study of the subject. On many of the minor points of distribution he agreed with Mr. Swinburne's conclusions, but from its present interest he thought the design of transformers was the most important subject dealt with in the paper, and to that he would confine himself. It was interesting to notice that the author had arrived at his present conclusions by a zigzag path, as was seen by a reference to the *Journal* for 1888, where, in the discussion of a paper by Prof. Forbes, Mr. Swinburne said: "I notice a slip where Prof. Forbes said that some transformers would be more efficient if the iron circuit were open. As I fell into the same error myself, I may point out that the waste of energy is $\int l\,d\,\mathrm{H}$," and so on. He (Mr. Mordey) would first sum up the author's present grounds for preferring open-circuit transformers. They were (1) that iron is wasteful, hysteresis loss heavy and continuous; (2) that losses are easily ascertainable by calculation only, from C^2R in the conductor, and by Ewing's or Hopkinson's curves for hysteresis (which he says is constant for all loads) and by calculation for the eddies; (3) that these phenomena in iron and action of transformers being understood fully, that only "phenomenal iron" can improve closed-circuit transformers; (4) that tests of closed-circuit transformers by various observers showing high efficiency are wrong, as such efficiencies do not agree with the author's calculations; (5) that magnetising current was large, even in the closed circuit type. On the question of these losses Mr. Mordey said that careful tests were needed to decide the points, not calculations. Many independent observations on closed circuit transformers by various methods, such as the calorimeter method used by Prof. Ayrton and others, the "split dynamometer" method devised by Mr. Blakesley, etc., had shown the efficiency to be very high. The method he had himself devised and alluded to in 1889 - viz., finding the steady temperature to which the transformer is raised when working at a known output, and then determining the loss by supplying, with direct currents, sufficient power to maintain this temperature—led to similar results. Recent tests of a six-kilowatt transformer of his own design by the latter method gave the loss on open circuit as 110 watts, and at full load 205 watts, of which 176 are accounted for by $C^2 R$ in the copper. This leaves only 29 watts for the iron losses at full load, whereas at no load they amounted to 110. On calculating the theoretical iron loss from Ewing's curves it came out 180 watts at the magnetisation employed. These results show that as the loss in the copper increases, the iron losses diminish, and that conclusions based on the assumption that the iron losses are constant and can be calculated from Ewing's curves, are erroneous. On the basis of the above tests, the efficiencies at various loads of the particular transformer were calculated to be as follows, the first and last being determined by experiment, the intermediate filled in by calculation.

	Efficiency.	
Full load	96·7	
¾ ,,	96·2	approximate.
¼ ,,	92·1	,,
⅛ ,,	86·7	,,

At no load the total loss was 1·8 per cent. of the full output, and the apparent loss—viz., C × V—3·1 per cent., the lag between E.M.F. current (determined simply from the ratio of the true to the apparent waste) therefore being 53deg. and 54deg. On the important subject of "all-day efficiency," which Mr. Swinburne finds to be very low in closed-circuit transformers, Mr. Mordey gave the following numbers as relating to the transformer above mentioned, which was one of the Brush Company's ordinary type.

Full load for four hours (20 hours).	All day efficiency.
¾ ,, ,, ,,	86
½ ,, ,, ,,	82·7
¼ ,, ,, ,,	68·6
⅛ ,, ,, ,,	52·6

He remarked that the small difference between the steady temperature of transformers working at no load and at full load was noticed by him in 1889. For instance, in one case this rise of temperature was 43deg. F. at no load, whilst at full load it was 48deg. F. only. For this observation no one could infer that either the transformer was very inefficient, or that the loss in the copper was very small, or that some other explanation was needed. Now, he knew that neither of the first two suppositions was correct, hence the necessity for some other explanation. Just before the meeting Prof. Ayrton had shown him some tests of one of his transformers, made by Blakesley's method. These tests conducted by Prof. Ayrton confirm his own, and as an instance of this gave the following numbers, which, he said, were taken from several pages of concordant figures :

	Watts.	Iron losses (watts).	Efficiency.
210	2,363	3	94·1
,,	907	69	90·4
160	2,638	21	93
,,	2,425	18	93·8
,,	849	69	90

These tests, together with many others made by disinterested observers, all point to the conclusion to which he had been led—viz., that the losses in the iron decrease with the load.

He submitted that these results, if correct, upset every one of the author's bases. But, even if Mr. Swinburne's contentions were true, the low "plant efficiency" obtained would seriously interfere to prevent the practical use of transformers constructed in accordance with his views. The author confesses to three-tenths of the plant being required to supply the magnetising current, but says that closed-circuit transformers require two-thirds as such, which is by no means the case. The use of condensers would reduce this great disadvantage of open-circuit transformers, but it must be remembered that condensers would also reduce the small disadvantage of closed-circuit transformers. If satisfactory condensers could be obtained (and he congratulated the author on the progress he seemed to have made in that direction), he thought the outlook for closed magnetic circuits was better than ever. The best plan of all was to make apparatus so that it could be left to work in its simplest form.

Mr. Crompton thought the results of his own tests on transformers would confirm Mr. Mordey's observations, but they also enabled him to contradict some of the statements made by that gentleman. In the first place the number of hours required for transformers to attain a steady temperature was much greater than Mr. Mordey would have us believe, for he (Mr. Crompton) had kept them running for 30 hours and still the temperature was not constant. He had also kept both a "Hedgehog" and a closed-circuit transformer of equal output on for 20 hours, the final temperature of the former being 120deg. F., whilst that of the latter was 212deg. F. His experience with the Hedgehog type in the lighting of Chelmsford had been satisfactory. Referring to "all-day efficiency," he said most people speak of the efficiency of transformers being 90 per cent. at half load, as if this was their normal working condition. This load was far above the average even during lighting hours. It might be approximately right for shops and other places where the probable load is readily ascertained, but for private houses it was much too high. Taking the case of a customer whose lighting bill, at 8d. per unit, amounts to £20 a year, he said such a house would require a 50 to 60-light transformer, and the average consumption throughout the year would be 70 watts. The transformer would thus be working on an average at $\frac{1}{16}$th its full load. It was curious to notice that in the transformer mentioned by Mr. Mordey (see Table III.) the iron losses at light loads were about 69 watts, and thus the yearly efficiency would come very near indeed to 50 per cent., the number he gave three years ago. He would have been glad if Mr. Mordey had given the statistics of some of the transformer stations with which he was connected, in the shape of the ratio of energy paid for to energy sent out from the station. This, he said, was the important point, and at present it appeared that transformer plants were using about 2½ times as much coal, per unit sold, as direct systems. All this extra coal, he submitted, was spent in heating the transformers. Banking transformers and distributing at low pressure would diminish this loss, but, after all, what did this come to? Simply that you put down a high-pressure line, with its expensive insulation and a transformer at the end of it, whereas with continuous currents a rather heavy feeder, with cheap insulation, was all that was required. Transformers, he said, were more easy to manage than was imagined, and were in this respect much better than secondary batteries. On the question of "storage," he could not agree with Mr. Swinburne's opinions, for in stations subject to uncertain loads, the employment of accumulators to the extent of 20 or 30 per cent. of the total output enabled the working expenses to be reduced immensely. In his opinion, the reason why storage is not used in America was that the loads were fairly steady, and a satisfactory storage cell was not to be had there.

Mr. Addenbrooke remarked that Mr. Swinburne was under a wrong impression when he stated that probably no existing company intended changing their system of supply, for he (Mr. Addenbrooke) well remembered that when Mr. Ferranti took out his first patents for transformers the subject of sub-stations and low-pressure distribution was thoroughly appreciated by the inventor. At that time, however, it was impossible to found sub-stations, but it had always been the intention of Mr. Ferranti, as well as of the House-to-House Company, to adopt this system whenever they could. This cutting-out or in of transformers at such stations could be effected either automatically or by hand on the lamp-lighter principle, and with either method a difference of 1 or 2 per cent. in the efficiency of the transformers would be a matter of little importance.

Mr. Evershed regretted that the diagrams belonging to the paper were not issued with the proofs, for without them it was very difficult to follow the reasoning. He described as admirable the explanation of how alternating dynamos act as motors, and said the action was much easier to understand on the armature reaction theory than by the older ideas about self-induction. Referring to the compound machines, mentioned on slip 7, where the magnets are excited by a redressed alternating current, he enquired how the sparking could be got over. On slip 8 the author says cast-iron magnets would not respond quickly to armature reactions, but he (Mr. Evershed) failed to see why this should be so, for the high specific resistance of the iron would prevent Foucault currents almost as well as laminated wrought iron. In conjunction with Mr. Vignoles he had made many experiments on the loss by hysteresis in different samples of iron, and had never found a sample give more than 25 per cent. more loss than Ewing's specimen ; only one sample gave this value, and it was an ordinary bar taken out of a smith's shop. In most cases the losses are about 5 per cent. more than that found by Ewing. On the subject of efficiency of transformers, he said Mr. Swinburne had not taken a good design of closed-circuit converter with which to compare his "Hedgehog."

Mr. Swinburne here remarked that in his B. A. paper he had given the best proportions of copper and iron for the closed-circuit form, but in this paper he had taken an average of the various forms in the market.

Mr. Evershed said that to be anything like a good design there should be much more copper in it, about 2,000 turns in the primary instead of the 400 given. This would reduce the iron loss to 40 watts instead of 120, and the exciting current would be reduced to ·08 instead of ·3 amperes required by the open-circuit type. Nevertheless, if good condensers could be obtained, the large exciting current would not be a serious defect. The subject of open *versus* closed circuit transformers had occupied his attention for some time, and he found that if you cut the iron circuit of one of the latter form its efficiency is increased. Such being invariably the case, he said, why not "go the whole hog or none?" and do away altogether with the iron core. Recently he had worked out the dimensions of a 10-h.p. transformer made on this plan, and found that at a frequency of 70 it would require two tons of copper. If, however, the frequency was raised to 210, the weight was reduced to 200lb., and the saving resulting from the absence of a core amounts to 20 per cent. per annum on the cost of the transformer. Difficulties might be experienced in making alternators for such high frequencies, but so far as coreless transformers were concerned, high frequency was decidedly advantageous.

LEGAL INTELLIGENCE.

REGINA v. THE FAREHAM ELECTRIC LIGHT COMPANY.

This case was tried before the Lord Chief Justice of England and a common jury at the Winchester Assizes on Tuesday.

Mr. Bucknill, Q.C., and Mr. Bovill Smith were for the prosecution ; Mr. Bullen appeared for the company ; Mr. J. Alderson Foote appeared for a syndicate employed by the company and indicted with them ; Mr. James Blake, one of the defendants, appeared in person.

This indictment was against the defendants for having obstructed some highways in the town of Fareham by digging holes and erecting posts and wires for the purpose of inaugurating a system of electric lighting, which is now, and has been for some little time past, in operation. It was said that the posts were an obstruction to the highway, and even in some cases dangerous. There was, however, no real dispute as to the facts. Early in 1890 an agreement was entered into by the Fareham Local Board and Blake, on behalf of the Fareham Electric Light Company, whereby the Local Board granted to the company, "so far as they lawfully could," leave and license to erect all necessary posts and wires for the supply of electric light. In June a contract was entered into between the electric light company and the Local Board for the lighting of the town by electricity for a term of three years. At that time, and for many years past, the local gas company had supplied the Local Board with gas for lighting the town, and the gas proprietors were practically the prosecutors in the present case, their contention being that the Local Board could not delegate to the electric light company the power of erecting posts in the highway.

At the end of the arguments his **Lordship** said he must direct an acquittal. Undoubtedly the posts would have been an obstruction but for the statutory powers given to the Local Board by the Public Health Act, 1875. He then referred to Section 161 of that Act, and said he considered "other means of lighting" mentioned in it included electricity, even although electric lighting was practically unknown when that Act was passed, and that under the section the Local Board could contract with the electric light company. He directed the jury to find all the defendants not guilty.

PHYSICAL SOCIETY.—Feb. 27.

Prof. W. E. AYRTON, F.R.S., President, in the chair.

Prof. A. Gray, M.A., was elected a member of the society.

The following communications were read:

"Proof of the Generality of Certain Formulæ Published for a Special Case," by **Mr. Blakesley**; **"Tests of a Transformer,"** by **Prof. W. E. Ayrton, F.R.S.**, and **Mr. J. F. Taylor.** In 1888 Mr. Blakesley published a number of formulæ relating to the measurement of power, etc., in alternating-current circuits by means of electro-dynamometers, one of which had its two coils independent and placed in different circuits. These formulæ were deduced on certain assumptions, the chief ones being that the currents and magnetisations varied harmonically, and that the magnetic stress in the iron was proportional to the ampere-turns. The present paper shows that the above assumptions are not necessary to the truth of the resulting formulæ. To take the case of a transformer, let alternating-current ammeters be placed in the primary and secondary circuits, and a direct-reading "split dynamometer" have a coil in each circuit. Let D_p, D_s, and D_{ps}, be the respective readings of these instruments, then, whatever be the law of variation of the currents,

$$D_p = \sqrt{\frac{1}{T}\int_0^T A_p{}^2\,dt},$$

$$D_s = \sqrt{\frac{1}{T}\int_0^T A_s{}^2\,dt},$$

and,

$$D_{ps} = \sqrt{\frac{1}{T}\int_0^T A_p A_s\,dt},$$

where A_p and A_s are the values of the primary and secondary currents at any instant, and T the time of one complete alternation. If i be the total induction in the core, P and S the numbers of turns of wire on the primary and secondary respectively, V_p and V_s the terminal pressures, p the resistance of the primary coil, and s the resistance of the whole secondary circuit, then the following equations hold at any instant.

$$V_p = p\,A_p + P\frac{di}{dt} \qquad \frac{di}{dt} = \frac{s}{S}A_s.$$

Therefore $V_p = p\,A_p + \frac{P}{S}\,s\,A_s$. Multiplying both sides by A_p, we get $A_p V_p = p\,A_p{}^2 + \frac{P}{S}\,s\,A_p A_s$, and integrating from $t = 0$ to $t = T$ and taking the mean

$$\frac{1}{T}\int_0^T A_p V_p\,dt = \frac{p}{T}\int_0^T A_p{}^2 dt + \frac{P}{S}\ \frac{s}{T}\int_0^T A_p A_s\,dt$$

or watts in primary $= p\,D_p{}^2 + \frac{P}{S}\,s\,D_{ps}$ quite independent of the laws of variation of A and V.

The power lost in heating the iron core was also shown to be $s\,\frac{P}{S}\,D_{ps} - D_p.^2$ Other formulæ, such as that given by Mr. Blakesley, expressing the primary volts in terms of the dynamometer readings, are shown to be true generally. On the subject of transformer magnetisations, the authors state that it is desirable not to speak merely of the ampere-turns, but also of the self-induction, for they had reason to believe that the magnetising value of an ampere-turn varies. Defining the self-induction of the secondary by the equation $L_s = \frac{dN}{dA_s}$, N being the total flux through the secondary, they show geometrically (assuming harmonic variations) that if L_s diminishes the efficiency increases, and at the same time the phase angle, θ, between the primary and secondary currents and the magnetic lag, ϕ, decrease. On comparing this theoretical deduction with the results of experiment they find a good agreement, as will be seen from the following table:

Frequency.	Efficiency.	L_s	θ	ϕ
160	96·3%	·0017	113°	0° 24′
160	92%	·0368	169°	18° 24′
160	85·4%	·1241	174·6°	45° 36′

Similar results were obtained in different sets of experiments. It was also noticed that as the secondary current is increased the efficiency rises to a maximum and then diminishes, whilst L_s, θ, and ϕ diminish and then rise again, the current which gives the maximum efficiency coinciding almost exactly with that which gives minimum values to L_s, θ, and ϕ.

The methods employed in making the tests are described in the paper, and the formulæ used in working out the results are there demonstrated. Amongst the facts deducible from the experiments are the following:

1. With constant frequency the ratios, $\frac{V_s}{V_p}$ and $\frac{D_s}{D_p}$, increase as the primary volts rise.
2. With frequency constant, and primary volts constant, $\frac{V_s}{V_p}$ decreases and $\frac{D_s}{D_p}$ increases as the secondary current increases.
3. With constant secondary current L_s decreases as the primary volts are increased.
4. With small constant secondary currents, the efficiency diminishes as the frequency increases.
5. For large secondary currents the efficiency is approximately independent of the frequency.
6. Shunting the secondary with a condenser increases the efficiency.

The transformer on which the tests described in Prof. Ayrton and Mr. Taylor's paper were made was of the Mordey type, having been kindly lent by the Brush Electrical Engineering Corporation.

"Further Contributions to Dynamometry," by **T. H. Blakesley, M.A.** The object of Mr. Blakesley's paper was, in the first place, to show what sort of physical quantities could be advantageously evaluated by using electro-dynamometers of two coils of low resistance in circuits conveying electric currents. The meaning of a dynamometer reading was explained to be the mean value of the product of two currents, either steady or undergoing any periodic variations with sufficient rapidity. In mathematical language, such an instrument measured $\frac{1}{T}\int_0^T C_1 C_2\,dt$, where C_1 and C_2 were the instantaneous values of the currents in the two coils, including, of course, the common case where these currents are identical. Any physical quantity whose value was such a product, $C_1 C_2$ multiplied into something which was independent of the time, and which, therefore, on integration came outside the integrator, was well adapted to have its mean value given by such instruments. Power was such a quantity, being merely (current)^2 × resistance. The square of an E.M.F. was another such quantity, but he did not wish to restrict the method to such evaluations. It follows that any quantity whose instantaneous value can be expressed by terms each quadratic in current, and whose other factor was independent of time, could have its mean value expressed in dynamometer readings. In addition, the particular place and mode of coupling of the dynamometers was indicated by the instantaneous equation, as well as the factor to be applied to each reading. *Thus the equations are made to indicate the practical arrangement to be adopted, and the use to be made of the observations* in each case. Examples were given for the cases of transformers in series and parallel, and special applications of the method were suggested in the measurement of the power employed in such diverse apparatus as voltameters subject to direct or variable currents of any sort, welding machines, parallel generators. tuning-fork circuits, vacuum discharges, and imperfect condensers. For parallel generators, the power of each could be separately estimated; and in the case of electric welders, the power employed in the welding circuit was shown to be measurable without introducing any resistance whatever into that circuit. **Mr. J. Swinburne** said the author's assumption that there is no back or forward E.M.F. in the primary and secondary circuits of transformers, except that due to $\frac{di}{dt}$, where i is the total induction in the core, was unwarrantable, for in all real transformers there was a "drop" due to waste field, and this made the split dynamometer method useless. It makes the full load efficiencies too high, and this, he thought, accounted for the extraordinary results obtained by Prof. Ayrton and Mr. Taylor. If a dynamometer be used at all, it should, he said, be used as a wattmeter, the moving coil of one turn being joined in series with a non-inductive resistance and put as a shunt to the primary. The power absorbed by the instrument itself should be then determined, and the power given out by the secondary measured by the same instrument, if the secondary be not non-inductive. Any errors due to self-induction in a wattmeter are, he said, equally present when it is called a split dynamometer, and in addition to this, the wattmeter as a split dynamometer precludes the possibility of measuring power. **Mr. Mordey** said the results obtained by Prof. Ayrton and Mr. Taylor confirmed experiments he had made himself by an entirely different method, for he found that the losses in the iron decreased considerably as the secondary current increased, and this gave increased efficiency. In his experiments he kept the load constant until the transformer attained a steady temperature, and then substituted a direct current for the alternating one, varying its strength until the same steady temperature was maintained. The power thus supplied is a measure of the loss in the transformer under the working condition. A six-kilowatt transformer tested by this method gave a loss of 110 watts at no load, and at full load 205. Of this 205, 176 was accounted for by the loss in the copper coils, leaving only 29 watts as the iron losses at full load. Figures which he quoted from Prof. Ayrton and Mr. Taylor's paper showed the same general result.

A "Note on Electrostatic Wattmeters," by Mr. J. Swinburne, and a paper on "Interference with Alternating Currents," by Prof. W. E. Ayrton, F.R.S., and Dr. Sumpner, were postponed.

MARCH 6th, 1891, Prof. W. E. AYRTON, F.R.S., President, in the chair.

Mr. H. A. Miers, M.A., and Mr. W. Lucas, M.A., were elected members of the society.

Mr. James Swinburne read a "**Note on Electrostatic Wattmeters.**" After referring to the history of the electrometer method of measuring power developed by alternating currents, the author pointed out that the necessity for taking two readings from which to determine the watts might be obviated by having the quadrants separate instead of connected in pairs, as in the ordinary method. Non-inductive resistances are connected to the transformer, motor, or other apparatus in which the power is to be measured, so as to be in series with the apparatus, and on opposite sides of it, and the four ends of these two resistances are connected with the four quadrants. Under these circumstances the deflection of the needle is a measure of the watts. To increase the maximum deflection obtainable, so as to make an instrument capable of being read by a pointer, the needle is made in two halves and fixed one below the other on the same stem, and instead of quadrant boxes, semicircular boxes are employed. In this way a range of about 130 deg. is obtainable. **Prof. Perry** enquired as to what kind of law the instrument had, and **Mr. Blakesley** asked whether it was convenient to use. **Mr. E. W. Smith** pointed out that there was no necessity to take two observations in the ordinary electrometer method, for by using a false zero one deflection gave the watts. Further, the use of the false zero rendered it unnecessary to employ any other voltmeter when experimenting at constant pressure. The **President** said the historical part of the paper was not quite correct, and recalled attention to the fact that when high pressures were used, a single reading obtained with the ordinary method of connecting up gave the power. For ordinary low voltages, however, the false zero method described by Mr. Smith was very convenient. **Mr. Swinburne,** in reply to Mr. Smith, said the observation of the false zero really meant another reading. As to the law of his wattmeter, referred to by Prof. Perry and the president, he said he never calculated a law, but calibrated the instruments directly.

Prof. S. P. Thompson, D.Sc., now took the chair, and a paper on "**Interference with Alternating Currents,**" by **Prof. W. E. Ayrton, F.R.S.**, and **Dr. Sumpner**, was read by the latter. The paper relates to the phenomena which occur when alternating electric pressures are impressed on circuits made up of various combinations of resistances, condensers, arcs, and inductive coils; to the characteristics of alternators; to the properties of transformers, and to the peculiarities exhibited by the Ferranti mains. In one of the experiments an inductive coil and a condenser were connected in series, and a pressure of 25 volts, as measured by a Cardew voltmeter, impressed on its terminals; the pressures on the two parts, measured in the same way, were 110 and 104 volts respectively, thus showing that each of the two parts was much greater than the whole. On joining a condenser and inductive coil in parallel, an ammeter in the main circuit indicated 5·5 amperes, whilst those in the branches showed 6·4 amperes passing through the condenser and 10 amperes through the coil. Other experiments of a similar nature were described, and it was pointed out that the ratio of the sum of the two parts to the measured total may be large, being about eight in the case first mentioned. Theoretically, this ratio might be anything, depending as it does on the phases of the pressures in the two parts, and these phases are determined by the ratio of the impedance of the coil to its resistance; practically, however, it was not easy to get a coil of large self-induction and very small resistance. Alternate-current arcs and condensers give results of the same general character as those above described, as also do arcs and inductive coils, such as the regulating coils of lamps; this may cause considerable error in estimating the power supplied to such lamp. The magnitude of the error was found to depend greatly on the quality of the carbons and the character of the arc. With bad carbons and a hissing arc the error was very great, but with good cored carbons burning steadily, it was not very serious. Combinations of inductive and non-inductive coils exhibit marked peculiarities, particularly if the inductive one be a transformer coil. This last arrangement gave distinct evidence of interference, or difference of phase when the secondary of the transformer was open, but when closed and with a moderate load, the difference of phase disappeared, thus showing that, under these circumstances, the primary coil had no appreciable self-induction. On the subject of alternator characteristics, a graphical method of drawing the E.M.F. curve from the terminal curve was described, and the dependence of the terminal curves on the character of the external circuit pointed out. Keeping the speed, exciting current, and armature current constant, the pressure between the terminals was shown to be dependent on whether the external circuit consisted of condensers, resistances, or inductive coils, the pressure being greatest in the former case and least in the latter. The true E.M.F. of the dynamo, however, was the same in all the cases, but it became less as the armature current increased. From these results the authors conclude that the drop in E.M.F. with large currents is due to reaction on the field, but that the change of terminal pressure cannot be all attributed to this cause. Transformers, it was shown, are powerful controllers of phase, for the primary and secondary currents are nearly always circulating in opposite senses, the phase angle for a one-to-one Mordey transformer experimented on varying from 170deg. at no load to 180deg. at full load. The relation between the strengths of the primary and secondary currents, A_p and A_s, was found to be a linear one, of the form $\frac{P}{S} A_p = \alpha + \beta A_s$, where P and S are the numbers of turns in the primary and secondary respectively, and α and β constants, α representing the exciting current and β being nearly unity. The phase angle, ϕ, between the currents was given by the equation,

$$-\cos\phi = \frac{\frac{1+\beta^2}{2} A_s + \alpha\beta}{\beta A_s + \alpha}$$

The results of numerous experiments on a transformer of the Mordey type, in which coils having different number of turns were put in parallel with each other, were given. In some cases resistances were put in circuit with the coils, and in others one or more of these resistances were cut out. Remarkable interference effects were thus produced, for in some combinations the volts or currents were additive, whilst in others they were nearly differential. In connection with the Ferranti effect experiments had been made by putting a condenser on the terminals of the secondary of a transformer, and noting the resulting increases in pressure, both in the primary and secondary circuits. The results obtained with a given condenser and approximately constant secondary pressure show: 1. That whether the transformation be up or down, the percentage rise in the secondary is greater than that in the primary. 2. That these percentage rises diminish as the secondary current increases. 3. That they increase with the ratio of transformation. 4. That the rise in the secondary may be considerable without that in the primary being appreciable. 5. That the rise in the secondary still persists, even when large currents are flowing. These facts lead the authors to believe that the "Ferranti effect" is due to some kind of interaction between the cable condenser and the self-induction of the transformer, and that it is not due wholly to armature reactions in the dynamo. In the discussion on the paper, **Mr. Swinburne** said the character of the "Ferranti effect" had been wrongly stated, for he understood Prof. Ayrton to say that the pressure between the Ferranti mains was greater at the London end than at Deptford. This, he contended, was impossible. He also said the effects now described of putting a condenser on the secondary of a transformer, and noticing the rise in both primary and secondary volts, were due to the waste field of the transformer. In large transformers, such as those at Deptford, the magnetic leakage was proportionately much less, and no such effects would be noticeable with them. Referring to the relation between the primary and secondary currents in transformers, he said it was convenient to look at the primary from two points of view, and consider one part of it as producing the magnetisation, and the other as neutralising the effect of the secondary current. **Mr. Mordey** described an experiment on armature reactions in alternators, in which one of the armature coils of a 50-h.p. machine was isolated from the rest, and connected directly to a Cardew voltmeter. On varying the load from 0 to the full output (20 amperes), the voltmeter on the isolated coil was quite stationary, thus showing that no appreciable armature reaction occurred.

Mr. E. W. Smith remarked that the formula connecting the primary and secondary currents holds true over a very wide range, for he had experimented on a Kapp transformer which gave (α) constant and $(\beta) = 1$ for frequencies varying from 20 to 200. **Mr. Blakesley** gave the following formula as applying to transformer currents generally

$$\left(\frac{A_p}{A_s}\right)^2 = \frac{n^2}{m^2}\left\{(1 + kr_2^2) + \frac{qr^2}{v}\right\}$$

Where r_2 = resistance of secondary, v is proportional to the frequency, m and n the primary and secondary turns, and k and q are constants depending on the disposition of the iron. This formula he found to very nearly represent Ferraris results, and he hoped others would test its applicability to various types of transformers. He believed himself to be the first who carried out an interference experiment, when he put a condenser in parallel with an inductive coil six years ago. He mentioned the matter now because that arrangement had been put forward by Mr. Glazebrook in explanation of the "Ferranti effect." Mr. Glazebrook, however, had made an error in stating that under certain conditions one of the currents may become infinite. **Dr. Thompson** thought the word "interference" had been used in a somewhat different sense to its ordinary usage in optics, and asked for an authoritative definition of its meaning in the paper under discussion. The experiments on the alternating arc he considered very remarkable, as well as those on the dynamo which give various terminal pressures when its E.M.F. and current were the same, but the external circuit of different character. **Prof. Ayrton** pointed out that the measurements on the rise of volts by putting on condensers mentioned in the paper were not strictly analogous to those made by Mr. Ferranti, for his were made by pilot transformers—one placed between the primary terminals of the Deptford transformer, and the other on the secondary of the London transformer—whereas, in the cases now brought forward the volts measured were those at the primary and secondary of the same transformer. On the subject of arc lamps, he said that

Messrs. Kolkhorst, Thornton, and Weekes, who made the experiments, found that great lag only occurred when the carbons were bad and the arc hissing. If the apparent and the true power spent in such an arc were measured, a great difference existed between them. Dr. Hopkinson, he said, had shown that this might be expected, if the arc had a constant back E.M.F. which changed sign with the direction of the current.

A paper on "The Theory of Dissociation into Ions and its Consequences," by Prof. S. U. Pickering, F.R.S., and another on "Some Points in Electrolysis," by Mr. J. Swinburne, were postponed.

COMPANIES' REPORTS.

DIRECT SPANISH TELEGRAPH COMPANY.

The report of the Directors for the half-year ended December 31 shows, after providing for debenture interest, a profit balance of £6,598. They recommend a dividend at the rate of 10 per cent. on the preference and one of 6 per cent. per annum, together with a bonus of 1 per cent. (both tax free), on the ordinary shares, thus making a total distribution of 7 per cent. for the year on the latter. The sum of £566 will be carried to the contingencies account.

LONDON ELECTRIC SUPPLY CORPORATION.

Report of the Directors to be presented to the shareholders at the fourth ordinary general meeting to be held at the Cannon-street Hotel, E.C., on Friday, the 13th inst., at 12 o'clock.

The general position of the works is described in the engineer's report appended hereto. The causes which led to the fire at the Grosvenor distributing station are stated in the engineer's report. The Directors are assured that with the measures now being taken for the equipment of the permanent distributing stations, any recurrence of such a calamity will be impossible in future. The premises damaged by the fire were insured, and are now being reconstructed in the most substantial manner. The interruption to business and the loss of income caused by the fire has been serious, and the Directors regret that it will not be possible to declare any dividend upon the preference capital. The portion of the year during which supply was suspended is a period at which the revenue is, under ordinary circumstances, at its maximum, but, owing to the severity of the winter, revenue in excess of the ordinary rate would have been produced, which, had it been received, would have enabled the Directors to pay a dividend on the preference capital. The results of working for the short period that ensued between the closing of the Grosvenor station and the cessation of supply on November 15, confirms the statement made in the last report, that the concentration of the whole of the generating machinery in one establishment, under the control of the chief engineer, would secure material advantages in supervision and economy. During the past year statutory powers have been acquired over several metropolitan parishes, which have led to a more economical and beneficial disposition of the works. The Board are making no applications for further powers this year, and will limit their parliamentary business to defending themselves against opposing interests. Notwithstanding the loss of certain old customers after the fire, new applications for current are coming in from day to day, and large demands are arising in certain portions of the authorised area in which, hitherto, there has practically been none. Works are now in hand with a view to meeting the material extension of the business which may be anticipated. Meanwhile supply of current was resumed on the 15th February, and customers are being connected to the new underground mains as rapidly as possible. The Directors retiring, as provided by the articles of association, are Mr. Francis Ince, Mr. Joseph Pyke, and Mr. Arthur F. Wade, all of whom are eligible, and offer themselves for re-election. The auditors, Messrs. Kemp, Ford and Co., who retire in accordance with the articles of association, offer themselves for re-election.

Engineer's Report.—Since I had the pleasure to report to you a year ago the engineering work of the Corporation has gone through a period of considerable activity under my direction. The concentric mains which you have manufactured under my patents have proved to be a complete success. Four concentric trunk mains have now been laid from Deptford to London, consisting in all of some 25 miles; they are laid in 20ft. lengths, and thus in the above distance there are no less than 6,500 joints. The work of laying was of necessity performed by unskilled labourers who had neither experience nor training in such work, and I am glad to say that on first testing the mains only some 20 joints out of the entire number proved to be defective; these defective joints are easily found and rapidly replaced. The mains have been thoroughly tested with a pressure of 17,000 volts, and have stood this test perfectly, and, as you are aware, they are now in daily use at a pressure of 10,000 volts, the normal pressure of your permanent work. With the sanction of the Board of Trade, earthing arrangements have been made in connection with the mains and other portions of your system, and the working is so satisfactory, that no disturbance whatever is caused to the telephone or telegraph systems; in fact, neither the Post Office nor the telephone company are able to say when your machinery is working. During the past year the whole of the machinery from the Grosvenor station has been removed to Deptford. The dynamos, which were designed to give 10,000 lights each, have been found capable of supplying with ease 15,000 lights each; consequently two larger engines for working these machines to their full capacity have been erected at Deptford during the year. These dynamos have been put into a thoroughly efficient state, and with this plant the work is now being done. In addition, two larger engines, each of 1,500 h.p., which had just been erected at the date of my last report, have been got into efficient running condition, and the necessary alterations are being made to the two larger dynamos (each capable of giving 30,000 lights), that will enable you to use them, now that your concentric mains are complete, at the full pressure of 10,000 volts (for which the machines were originally designed), instead of 5,000 volts, the pressure first used. These machines will be working at 10,000 volts pressure within the next three months, and you will then be in a position to generate current for 90,000 lights. It is not, however, proposed to supply more than two-thirds of this number at the same time, in order that a reserve of power sufficient to meet the requirements of the Board of Trade may be always kept in hand. With these two large machines supplying your circuits the first important stage of your undertaking will be completed. Great progress has also been made towards the next stage, though this work has not been pressed in view of making more rapid progress with that of the first stage. Nevertheless, more than three-fourths of the work of the next pair of dynamos has already been done. They will each be capable of supplying 200,000 lights, but in the first instance it is intended to supply engine power to each dynamo for 100,000 lights only, and by the end of another year from the completion of what I have called the first stage of your work, I expect to be in a position to report the completion of the second stage. You will then be able to supply 290,000 lights, less a proper reserve. Sufficient mains are already laid between Deptford and London to transmit the current which you will then have to dispose of. I desire to call attention to the fact that from the commencement of your operations to the present time, no engineering or electrical difficulties whatever have arisen which I have not been able to overcome, and at the present moment I know of no weak point in your system, and consider success to be now assured. It is a matter of great regret that a fire in your temporary distributing station in November last has caused a loss of the revenue which would otherwise have been earned, and which, owing to the extraordinary severity and darkness of the winter, would have been more than usually profitable. I am glad to say that this fire was not due to any defect of principle in your system, and could not have happened had your permanent distributing station been erected; but, as you are aware, it was an impossibility to erect the permanent station, the premises being occupied by the machinery which was then in course of removal to Deptford. The fire has, however, in some sense been beneficial, as it has allowed the permanent work to be pushed forward to an extent which could not otherwise have been possible, progress having been much delayed by the necessity of keeping a running business going during a period of progressive changes in the permanent system. The loss occasioned by the fire was not serious so far as destruction of apparatus was concerned, but was principally felt in decreased revenue returns. The suspension of supply enabled good progress to be made with the laying of distributing mains, there being at the present time some 18 miles laid and in use. It was important that this work should be pushed on, as the right to use overhead cables expires in the summer of this year, and the distributing mains being so well advanced, it has been deemed wise to discontinue the use of those cables. Your customers are now being connected to the permanent underground mains with the utmost possible speed. A most important work has been completed during the past year in erecting at Deptford switching gear which allows all or any of the machines to be used separately, or in combination. It has been further proved that the various machines can be worked together in parallel, a matter of considerable importance to successful working, as ensuring the maximum of efficiency and economy. The Corporation has secured sites for three additional distributing stations, and the work of installing them with the necessary apparatus is being proceeded with. These stations will all be in work during the present year, each having two separate sources of supply at 10,000 volts pressure, which is lowered at these stations and distributed at 2,500 volts, being further reduced to 100 volts before entering the wires of the customer, as in the case of the low-pressure system. At the time of my last report there were many parts of the system which were generally considered doubtful and more or less experimental; I refer more especially to the supposed difficulties of transmitting current from Deptford to London. The fact that current of 10,000 volts pressure is transmitted every day to London is the most complete answer to such doubts. The great advantage of the high-pressure system is apparent in that the loss involved in transmission of current from Deptford to the distributing stations is inappreciable, while the facilities for procuring coal and water there, sufficiency of room for machinery and appliances, and freedom from the legal and financial consequences attending the erection of generating stations in crowded neighbourhoods, cannot fail to tell their own tale in the working expenses of the current year.—S. Z. De Ferranti.

The statement of share capital on the 31st of December, 1890, shows that the capital consists of £1,000,000, divided into 200,000 ordinary shares of £5 each, and £250,000, divided into 50,000 preference share of £5 each; the former as authorised by the articles of association, and the latter by resolution of general meeting. The number of shares issued was 111,000 ordinary and 50,000 preference, all of the nominal value of £5. On the ordinary shares, £5 per share had been called up, and on the preference, £2; making the total paid up £555,000 and £153,043 respectively. £96,957 of preference shares had been issued, but not paid up. Of the ordinary shares, 89,000 (value £445,000) remained unissued.

No. II. statement of the report refers to loan capital on the 31st December, of which none had been borrowed at that date.

CAPITAL ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Dr.	Expended to Dec. 31, 1889. £ s. d.	Expended to Dec. 31, 1890. £ s. d.	Total expenditure, Dec. 31, 1890. £ s. d.
1. Expenditure to Dec. 31, 1889, £505,258 7s. 8d. Less depreciation £303 12 6 Total £504,954 15 2			
2. Buildings, freehold land, and general construction account at Deptford	102,728 7 4	15,750 9 9	118,478 17 1
3. Plant and machinery at Deptford	68,342 18 8	33,464 6 8	101,807 5 4
4. Mains, including cost of laying the mains from Deptford	24,137 7 9	71,872 3 6	96,009 11 3
5. Purchase of the business of Sir Coutts Lindsay and Co., Limited, including plant and machinery at Grosvenor station, goodwill, expenses, etc. ...	249,537 0 6	860 3 6	250,397 4 0
6. Mains, including cost of laying from Grosvenor station..	20,170 19 7	5,338 5 3	25,509 4 10
7. Transformers ..	26,632 18 5	9,258 7 7	35,891 6 0
8. Meters	1,682 11 8	3,166 16 7	4,869 8 3
9. Electrical instruments ...	2,289 14 1	2,237 10 8	4,527 4 9
10. Cost of provisional order ...	4,380 9 0	401 4 0	4,781 13 0
11. Tools	918 15 11	218 18 2	1,137 14 1
12. Distributing stations	185 15 6	792 8 0	978 3 6
13. Alterations to offices and stores, to 31st Dec., 1890, £3,431. 8s. Less depreciation, £262. 12s. 6d	3,168 15 6	48 6 9	3,217 2 3
14. Office furniture, £820. 1s. 3d. Less depeciation, £41	779 1 3	92 5 5	871 6 8
	£504,954 15 2	143,501 5 10	648,476 1 0
		Balance	59,566 19 0
			£708,043 0 0

Cr.	£ s. d.	£ s. d.
1. Ordinary shares, 111,000 of £5		555,000 0 0
2. Preference shares, 50,000 of £5, £2 paid	£100,000 0 0	
Less calls in arrear	210 0 0	
		99,790 0 0
3. Amounts received in anticipation of calls		53,253 0 0
		£708,046 0 0

REVENUE ACCOUNT FOR THE YEAR ENDING DECEMBER 31ST, 1890.

A.—To Generation of Electricity.

Dr.	£ s. d.	£ s. d.	£ s. d.
1. Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing same on the works..................		11,175 10 5	
2. Oil, waste, and engine-room stores		2,738 14 11	
3. Proportion of salaries of engineers, superintendents, and officers....		650 0 0	
4. Wages and allowances at generating station		3,747 1 2	
5. Repairs and maintenance, as follows:			
1. Buildings	142 5 4		
2. Engines & boilers	792 0 7		
3. Dynamos and exciters	103 8 8		
4. Other machinery and tools	79 14 6		
5. Transformers and accessories	14 11 0		
		1,132 0 1	
			19,443 6 7

B.—To Distribution of Electricity.

	£ s. d.	£ s. d.
1. Proportion of salaries of superintendents and officers	520 0 0	
2. Wages and allowances to linesmen, fitters, etc.	970 15 4	
3. Repairs, maintenance, renewals, and charges of mains of all classes, including materials and laying same, also wayleaves......	206 7 1	
4. Repairs, maintenance, and renewals of transformers, meters, switches, fuses, and other apparatus on consumers' premises	524 14 1	
		2,221 16 6

C.—To Proportion of Rents, Rates, and Taxes.

	£ s. d.	£ s. d.
1. Rents payable	1,424 4 5	
2. Rates and taxes	552 14 3	
		1,976 18 8

D.—To Proportion of Management Expenses.

	£ s. d.	£ s. d.
1. Directors' remuneration	1,000 0 0	
2. Salaries of secretary, engineers, accountants, clerks, and messengers	2,150 4 3	
3. Stationery and printing	148 1 2	
4. General establishment charges ...	527 13 1	
5. Auditors	52 10 0	
		3,878 8 6

E.—To Proportion of Law and Parliamentary Charges.

	£ s. d.	£ s. d.
1. Law expenses	585 2 2	
2. Compensation claims	66 16 9	
		651 18 11
Stores at 31st December, 1889		532 0 9
		£28,704 9 11

Cr.	£ s. d.
1. Sale of current, per meter, at 7¼d. per B.T.U. ...	16,280 6 11
2. Sale of current under contracts	9,701 19 2
3. Rental of meters, converters, and other apparatus on consumers' premises	1,137 6 2
4. Sale and repairs of other apparatus	1,099 3 2
5. Transfer fees	38 18 0
6. Running stores on hand at 31st December, 1890..	427 2 3
By balance...	19 14 3
	£28,704 9 11

NET REVENUE ACCOUNT FOR THE TWELVE MONTHS ENDING 31ST DECEMBER, 1890.

Dr.	£ s. d.
1. Depreciation on alterations to offices and stores ...	262 12 6
2. ,, ,, ,, ,, office furniture......	41 0 0
3. Reserve fund, being provision for bad and doubtful debts and other items	1,103 12 10
4. Fire account—Grosvenor	1,183 16 2
5. Revenue account—balance	19 14 3
	2,610 15 9
Balance carried forward...............	813 7 7
	£3,424 3 4

Cr.	£ s. d.
1. Balance from last account..	920 12 4
2. Interest on deposit account and sundry discounts	2,503 11 0
	£3,424 3 4

RESERVE FUND ACCOUNT.

Dr.	£ s. d.
1. Allowances made during 1890	775 3 4
2. Balance	1,000 0 0
	£1,775 3 4

Cr.	£ s. d.
1. Amount provided at 31st December, 1889, to meet further allowances off accounts, etc.	671 10 6
2. Amount transferred from net revenue account to meet further allowances at December 31, 1890	1,103 12 10
	£1,775 3 4
Balance	£1,000 0 0

GENERAL BALANCE-SHEET ON 31ST DECEMBER, 1890.

Dr.	£ s. d.
Capital account: Amount received as per account No. III......	708,043 0 0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc., to 31st December, 1890	29,401 7 10
Sundry creditors on open accounts	1,164 12 2
Reserve fund account	1,000 0 0
Net revenue account: Balance at credit thereof ...	813 7 7
	£740,422 7 7

Cr.	£ s. d.	£ s. d.
Capital account: Amount expended for works as per account No. III		648,476 1 0
Cash at bankers—		
Messrs. Coutts and Co.	1,361 11 8	
Messrs. Glyn, Mills, Currie, and Co.	416 13 11	
London and County Bank (Deptford)	129 3 4	
		1,907 8 11

Cash in hand	£34	4	7
Sundry debtors on account of contracts	40,158	7	9
Cost of redeeming debentures	30,000	0	0
Preliminary expenses	10,311	3	10
Sundry debtors for current	7,414	2	3
Other debtors	1,693	17	0
Running stores on hand at 31st December, 1890	427	2	3
	£740,422	7	7

NEW COMPANIES REGISTERED.

United States Power Syndicate, Limited.—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £50,000 in £10 shares. Object, to purchase the sole rights of manufacture and sale in the United States of America of inventions relating to hydro-carbon engines, and to carry on in the United States the business of mechanical engineers, ironfounders, and electrical engineers. The first subscribers are:

	Shares.
W. D. Priestman, Hull	1
S. Priestman, Hull	1
J. W. Barber, Sheffield	1
E. Priestman, Hull	1
W. Dent, Bellevue House, Woolwich	1
J. Priestman, 73A, Queen-Victoria-street, E.C.	1
A. Priestman, Temple-buildings, Hull	1

There shall not be less than five nor more than seven directors; the first are J. William Barber, Henry Pawson, Samuel Priestman, Josh Priestman, and Albert Priestman. Qualification, £500. Remuneration, £100 each.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £6,613.

City and South London Railway.—The receipts for the week ending March 7 were £731, against £753 for the previous week.

Commercial Cable Company.—The Company announce a quarterly dividend of $1\frac{3}{4}$ per cent. upon the outstanding stock of the Company, payable April 1.

Brazilian Submarine Telegraph Company.—A quarterly interim dividend at the rate of 6 per cent. per annum, payable on the 25th inst., is announced by the Directors.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £5,349.

Great Northern Telegraph Company.—The receipts for February were £20,800, and from January 1 to February 28, £41,600, against £39,400 last year and £42,000 in 1889.

Oriental Telephone Company.—The Directors have resolved to recommend a dividend of $2\frac{1}{4}$ per cent. per annum for the past year on the entire paid-up capital of the Company, which dividend, being payable to only the ordinary shareholders, is equal to $3\frac{1}{2}$ per cent. on their shares.

South of England Telephone Company.—Terms of sale of the property and business of this Company to the National Telephone Company have been arranged, and a meeting of shareholders of the former Company is convened for the 16th inst. to consider the proposal. The business is to be transferred as from the beginning of November last, and holders of preference shares in the South of England Company are to receive an equivalent amount of $4\frac{1}{2}$ per cent. debenture stock in the National Company, while one £5 ordinary share of the latter is to be issued for each 25 £1 ordinary shares of the South of England Company.

PROVISIONAL PATENTS, 1891.

MARCH 2.

3694. **Improvements in electrical switches.** Francis William Webb and Arthur Moore Thompson, Holly Bank, Crewe.

3740. **Improvements in electric meters.** Maurice Koechlin, 28, Southampton-buildings, London. (Complete specification.)

3748. **Improvements in the production of slabs and blocks for electrical insulators and other purposes, and apparatus to be used in the manufacture thereof.** Alexander McLean, 6, Bream's-buildings, London.

3755. **Improvements in automatic switches for electric currents.** Bernhard Dukes, 226, High Holborn, London. (Albrecht Heil, Germany.)

MARCH 3.

3765. **Improvements in and connected with electric arc lamps.** Luther Hamilton Buchanan, 70, Market-street, Manchester.

3789. **Improvements in the depolarisation of electric batteries.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (André Bellemain, France.)

3799. ***A new or improved solution or composition for charging electric batteries.*** *Ada Clark, 8, Quality-court, London.*

3828. **Improvements in electric signalling and lighting for the prevention of railway accidents, and for lighting railway and other carriages.** Sylvain Levy, 323, High Holborn, London.

MARCH 4.

3867. **Improvements in electricity meters.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow. (Complete specification.)

3868. **Improvements in arrangements and apparatus for electrically communicating with engine-drivers of railway trains and others, for signalling purposes and otherwise.** Frederick Thomas Hollins, "Saltley," Forest-drive, Leytonstone.

3893. **Improvements in electrical cables.** Walter Twiss Glover and George Edward Preece, Bridgewater-street, Salford.

3895. **Improvements in apparatus for transferring electric car batteries.** (Date applied for under Patents Act, 1883, Sec. 103, August 5, 1890, being date of application in the United States.) Frederick Gleason Corning, 76, Chancery-lane, London. (Complete specification.)

3904. **Electrical switches.** Thomas Percival Richards, 174, Beckenham-road, Penge.

MARCH 5.

3939. **Improvements in interlocking of points, signals, and electric signals.** William Henry Elliott, Railway Cottage, Thurles, co. Tipperary.

3946. **A non-inflammable composition which is also a non-conductor of electricity, and methods of producing the same.** Frederick Blake Pemberton, 44, Chancery-lane, London.

3957. **Improvements in instruments for measuring electricity.** Leslie Bradley Miller and Maurice Walter Woods, 34, Gray's-inn-road, London.

3967. **Improvements in portable electric safety lamps.** Theophilus Coad, 1, Quality-court, London.

3984. **Improvements in and relating to electric arc lamps.** Octave Patin, 45, Southampton-buildings, London.

MARCH 6.

4005. **Improvements in dynamo-electric machines.** Frank Bryan, 11, Brackley-terrace, Chiswick, London.

4044. **Improvements in electrical storage batteries or accumulators.** Robert Herbert Simpson, 11, Furnival-street, London.

4064. **Improvements in electricity meters.** George Hookham, 7, Staple-inn, London.

MARCH 7.

4099. **Improvements in electric arc lamps.** William Hopkin Akester, 57, Chancery-lane, London.

4120. **An improved imitation candle for use with electric incandescent lamps.** Walter John Fryer, 2, Kellett-road, Brixton, London.

SPECIFICATIONS PUBLISHED.

1890.

475. **Telegraphic, etc., communication.** Sack and Ziesel. 8d.

2108. **Switches for electromotors.** Whitmore and Akester. 8d.

3276. **Telephonic apparatus.** Whalley. 8d.

4004. **Electric discharge paths.** Barnett. 4d.

4992. **Recording electric measurements.** Gay and Hammond. 11d.

5199. **Treating copper-nickel matte.** The Electric Construction Corporation, Limited, and others. 4d.

5836. **Dynamo-electric machines, etc.** Radcliffe. 8d.

13044. **Electric lighting.** Bardonnaut and Juppont. 11d.

18589. **Electric railway signals.** Waddell. 8d.

1891.

83. **Electric guest calls.** Thomson (Striemer.) 8d.

624. **Electrical elevator apparatus.** American Elevator Company (Otis Bros. and Co.) 8d.

647. **Electric measuring instruments.** Lake (Weston). 8d.

649. **Electric elevators.** Lake. (Eickemeyer.) 11d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	$2\frac{1}{4}$
— Pref.	—	$1\frac{3}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$19\frac{1}{2}$
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	$2\frac{1}{4}$
Swan United	$3\frac{1}{2}$	$4\frac{3}{4}$
St. James'	—	6
National Telephone	5	$4\frac{3}{4}$
Electric Construction	10	$7\frac{1}{4}$

NOTES.

List of Members.—The list of officers and members of the Institution of Electrical Engineers has been issued corrected up to January 31st, 1891.

Amalgamation.—We see it stated that the gas company of St. Louis have paid three million dollars to obtain entire control of the electric lighting in that town.

Frankfort Exhibition.—Official recognition has been taken by the French Government of the Frankfort exhibition, and the office for Paris is announced as being at 99, Rue de Grenelle.

Old Students' Association.—A meeting will be held at Finsbury Technical College on Wednesday, March 25, when a paper will be read by Albion T. Snell, member, on "Coals, Coal Mines, and Coal Mining."

South Kensington Subway.—An official intimation was given on Monday of the withdrawal for the present session of the Bill seeking powers to construct an electric subway railway from South Kensington to Paddington.

Birkbeck.—The annual concert of the violin classes of the Birkbeck Literary and Scientific Institution, under the direction of Mr. T. E. Gatehouse, will take place on Saturday, March 21st, at 8 p.m.; unreserved tickets, one shilling.

Bradford.—Complaints are made by a correspondent in the local press that the Reference Library at Bradford is not lighted on Sundays. Now that accumulators are put in by the Corporation, he thinks the light should be available.

Hanwell Asylum.—The London County Council have authorised an expenditure of £3,000 for protection from fire at Hanwell Asylum, part of which is for fire-alarms and telephones.

Workhouse Telephones.—The recommendation of the committee of the Fulham Board of Guardians was adopted with reference to the acceptance of the estimate £28. 4s. 8d., from Messrs. Digby and Co., to supply the telephone in the offices of the workhouse.

Douglas.—Tenders are required for putting up and maintaining an electric light installation at Falcon Cliff, Douglas, Isle of Man, during season 1891, May to September. Particulars can be obtained of Mr. F. Rowe, secretary, Falcon Cliff Company, Villiers-chambers, Douglas.

Saunderson's Arc Carbons.—The patents of Mr. Apps, taken out in conjunction with Mr. Saunderson, for hollow arc carbons supplied with vaporised hydrocarbons, have been purchased by the representatives of the latter gentleman, and Mr. Apps retires from further connection with the Saunderson carbon.

Lewisham.—The Lewisham District Board of Works have decided to lodge an objection with the Board of Trade against the application on the part of the Crystal Palace and District Electric Lighting Company, for an extension of time within which to comply with the requirements of the statutory order issued last year.

Candle Power.—The eight "2,000-c.p." lamps in the streets of Warren, Ohio, when tested by Prof. Thomas with a Methven screen for the Municipality, only gave averages ranging between 385 and 1,036 candles. Is it not time that electrical engineers adopt a nominal candle-power somewhere about the actual truth?

Book Received.—We have received a copy of "Decorative Electricity," by Mrs. J. E. H. Gordon, with a chapter on "Fire Risks," by J. E. H. Gordon, B.A., illustrated by Herbert Fell (Sampson Low, Marston, Searle, and Rivington), the extension, with illustrations, of an article which appeared in the February number of the *Fortnightly Review*.

Hackney.—On condition that the Laing, Wharton, and Down Construction Syndicate, Limited, deposit with the Hackney District Board of Works the sum of £1,000, as security that they will carry out the duties devolving upon them in pursuance of their provisional order, the Board has given consent to the scheme of the syndicate for lighting Hackney by electricity.

The National Telephone Company have adopted the electric light in the switch-room of their Newcastle exchange, and have thereby greatly added to the comfort of their operators. Not only have they now a far better light, but also the air remains far purer than it did when they used gas. The contractors for the installation were Messrs. Barnett, Wynne, and Barnard.

Bath Report.—The accounts before the Bath Town Council ordered to be paid included one of 50 guineas for the report by Prof. Forbes on the electric light system. This report, said Mr. Sturges, is now being considered by the Electric Light Committee, who will in time present it with recommendations. It was a most able report, though some of its points were disputed by Mr. Massingham.

Electric Clocks.—The *Revue Technique des Inventions Modernes* (Brussels) describes some new and handsome types of electric clocks manufactured by Messrs. Peyer, Favarger, and Cie., of Neufchatel, and illustrates a central station for regulation of clocks by electricity with a town clock. These central clock regulators have been applied at Neufchatel, Basle, Zurich, Geneva, Nice, Milan, and other towns.

Chamber of Commerce.—A meeting of the Electrical Trades Section will be held at Botolph House, Eastcheap, on Friday (to-day) at 1.30 p.m., to receive the reports of sub-committees on (1) overhead wires, (2) telephone clauses, (3) Board of Trade form of accounts; also to consider the desirability of co-operation between the telephone and electric light companies for the purpose of placing wires underground in future.

Electrical Utilisation of Insects.—An electric apparatus supplies a strong light which attracts the insects and moths; a suction fan worked by the electric current draws them in when they approach the light, and carries them into a small mill, also worked by the electric current, where they are ground up and mixed with flour and thus converted into poultry food of excellent quality. This is said to be a Bavarian contrivance.—*Scientific American.*

Lighting Hours.—The data on electric lighting published by the Technical Institute, Milan, show that the theatres and cafés in Milan run an average per lamp of 1,800 hours per annum; clubs, 1,300 hours; hotels, 950 hours; shops, 750 hours; offices, banks, etc., 400 hours; private consumers only 320 hours; average over all, 750 hours per lamp. The average over all for gas is 650 hours, 1,707 cubic feet per inhabitant for private, and 495 cubic feet for public lighting.

Electrical Standards.—The Electrical Standards Committee met on March 12, when the following members were present: Mr. Courtenay Boyle, Major Cardew, Mr. Preece, Sir W. Thomson, Lord Rayleigh, Dr. J. Hopkinson, and Prof. Ayrton. Mr. Thomas Parker, chief electrician of the Electric Construction Corporation, Limited, Wolverhampton, and Mr. Hugh Erat Harrison, principal of the Electrical Standardising, Testing, and Training Institution, London, attended and gave evidence.

Telephone Subscriptions.—The majority of the Galashiels subscribers to the telephone decline to renew their subscriptions unless it is reduced to £6 per annum, and many Hawick subscribers have done the same. Three alternatives present themselves: the National Telephone Company may reduce their rates; they may hold out, and the bulk of the subscribers in these towns drop the use of the telephone; or the Mutual Telephone may set up a rival exchange. It is quite time the rates were brought within reasonable scope.

Guernsey Electric Railway.—Tenders have been received for working the Guernsey Railway by electricity on the parallel system, by means of an overhead conductor, including the supplying of the electrical plant, from the following firms: Siemens Bros. and Co., accepted; Westinghouse Electric Company, Limited; Brush Electrical Engineering Company, Limited; Electrical Engineering Corporation, Limited; Electrical Construction Corporation, Limited; Messrs. Crompton and Co., Limited; Thomson-Houston International Electric Company.

Telephone at Gravesend.—The Works Committee of the Gravesend Town Council, at the last meeting reported that they had considered the application of the South of England Telephone Company to establish telephonic communication between Gravesend, Rochester, Chatham and Maidstone, but the committee, thinking it more important that such communication should be with London, the town clerk was directed to write to Chatham (which was in communication with London) requesting a representative of the company to attend.

Laying a New Indian Cable.—The s.s. "Britannia," belonging to the Telegraph Construction and Maintenance Company, and commanded by Captain Woodcock, arrived in Madras on the 10th ult. She took out the shore end and 450 knots of the new duplicate cable, which is to be laid for the Eastern Extension Telegraph Company between Madras and Penang. The "Britannia" landed the shore end successfully at Cupid's Bow, and paid out about 10 miles of cable. She then buoyed the end, and returned to the harbour to await the arrival of the s.s. "Seine," another vessel belonging to the company, which is bringing out over 1,000 knots of the new cable. Mr. E. Riddle is the engineer in charge.

Communication to Coast Guard Stations.—Sir Edward Birkbeck, who is the chairman of the Royal National Lifeboat Institution, intends to call the attention of the House of Commons to the deficiencies in telephonic and telegraphic communication along the coasts of the United Kingdom, and to move: "That, with a view to the better prevention of loss of life and property in cases of shipwreck and to giving speedy information to lifeboat authorities and rocket apparatus stations, in the opinion of this House it is desirable that telephonic and telegraphic communication should be provided by Government between all the coast guard stations and signal stations on the coast of the United Kingdom, and, on such parts of the coast where there are no coast guard stations, the postal telegraphic offices nearest to the lifeboat stations."

Bromley.—Mr. R. G. Mullen, clerk to the Bromley Local Board, has had an interview with Sir Thomas Bloomfield, in which he has urged the great importance of the Local Board being allowed to charge 10d. per unit for electricity supplied. The result of the interview was that Sir Thomas promised to advise the Board of Trade to allow the retention of the charge upon condition that the Local Board agreed to section 52 of the order being altered, so that should the surplus in any year exceed 4 per cent. *upon the capital expenditure*, a proportionate reduction should be made on the charge for supply. The order as originally drafted provided that 5 per cent. should be the maximum. The Bromley Local Board have acceded to the stipulation.

Micro-Sismograph.—Photographic registration has been advantageously substituted by M. Baratta for the mechanical apparatus hitherto used for the registration of the indications by the micro-sismograph of the vibrations of the earth. A microphone placed in the ground is connected to an ordinary telephone; the diaphragm of this receiving telephone is connected by an aluminium wire to a small plate of the same metal carrying a concave mirror movable around an horizontal axis. A strip of sensitised paper is uncoiled before the mirror and receives the reflected rays of a lamp. The small variations of the membrane of the receiving telephone are amplified by the ray of light, and the trace of this ray is left in a permanent trace upon the sensitised paper.

The Edinburgh Exhibition.—Mr. J. A. Robertson, C.A., liquidator of the recent International Exhibition held in Edinburgh, has issued a circular stating that a first dividend of 13s. 4d. per pound will be paid to those creditors whose claims have been admitted. Preferable debts had been paid to the amount of £2,710. 16s. 3d., and the ordinary claims lodged amounted to £42,215. 4s. 8d. The subscriptions to the guarantee fund amounted to £26,559. 7s., and of that sum there had been received £25,594. 7s. The total receipts, including drafts on cash credit, were £102,539. 18s. 10d., and the total payment £101,083. 16s. 5d. There was a balance in hand on November 15 of £1,356. 2s. 5d. The sums received from exhibitors for space amounted to £12,974. 9s. 7d.; music and entertainment cost £12,053.

Telephone in the Potteries.—At a meeting called last week to consider the introduction of a telephone exchange into Rugeley, it was mentioned that in Stafford they had begun with six subscribers to the local exchange; there were now in that town 44, and many more about to join. Stafford was now in communication with 133 towns, and the number was being added to. If they could get 20 subscribers at Rugeley, that town would have the same advantages, and they would be able to converse with Stafford, Birmingham, Burton, and the Potteries, etc., for 3d. for three minutes' talk. The National Company's trunk system extended over 16,000 miles of wire, they had 26,488 exchange subscribers, and 172,173 calls were received daily, making a total of 344,346 messages per day. The proposal for the starting of the exchange at Rugeley was adopted.

Overhead Wires.—On behalf of the County Council's Bill for promoting the better regulation of overhead wires in London, Mr. Wolfe Barry gave evidence on Tuesday before the Committee of the House of Commons presided over by Mr. Stephen Williamson. He considered the Council were justified in taking powers to compel the telephone company to place their wires in subways if necessary. On the part of opponents, Mr. Winterbotham, solicitor to the National Telephone Company, gave evidence against the proposal to charge the company for the cost of registering and inspecting the wires. Their lines passed through 40 districts, and if they had to pay for the registration of their 12,000 wires they would have to pay no less a sum than £2,400 for that purpose alone. The chairman's decision is that the preamble had been proved, but various alterations were inserted.

The Storm.—The blizzard last week caused great destruction amongst telegraph wires, in the West of England especially. At the request of the Plymouth Corporation, the local manager of the Western Counties Telephone

Company sent a special gang of men to repair the telephone lines to Roborough, with instructions also to repair the lines of the Devonport Water Company, which run on the same poles to Crown Hill. The telephone lines in Plymouth have suffered very severely. Upwards of 100 lines have either broken down or been interrupted by broken wires falling across them. Efforts were made to put them in order at the earliest possible moment, special gangs of workmen being employed. In one case a skilled engineer was required at the graving docks, but, the wires being broken, no direct communication was possible to London. The message was sent to New York and back to London, and the man arrived the same evening.

Turbines.—As electric lighting extends, every country gentleman, every borough surveyor, will take careful consideration of all his waterfalls and river power to see how far he can utilise them for the generation of electric energy. For this he will need also the consideration of turbines, and will find exceedingly useful for his purpose a little work issued by Mr. Frederick Nell, 16, Mark-lane, on "The Victor Turbine." This book, while describing one special and efficient kind of turbine, gives numerous illustrations of very many manners of utilising water power for different purposes, and a great deal of interesting and important information upon waterwheels in general and the Victor turbine in particular, with tables of the horse-power developed by various-sized wheels under varying heads of water, hints upon improving the water ways, constructing weirs, and formulæ and tables for measuring the power to be obtained from any given stream.

Laboratory for Cambridge.—The Mechanical Workshops Syndicate of the Cambridge University have issued a memorandum touching the establishment of a school of engineering, and the erection of the buildings required for an engineering laboratory. They point out what has been done by other educational bodies in this direction, notably at the University College, Liverpool. They insist on the necessity of a scientific training as a basis for practical work, and on the indispensability of a properly fitted laboratory for this purpose. They estimate the sum required for such a laboratory at £20,000—a sum which, they allow, the university cannot be expected to contribute. They claim, however, that the establishment of such a school and laboratory in connection with the active scientific schools of this university is not a matter of mere local importance, and they hope to obtain the requisite funds, or a considerable portion of them, from external supporters.

Prince of Monaco's Yacht.—The electric lighting of H.S.H. the Prince of Monaco's yacht, "Princess Alice," has been placed in the hands of Woodhouse and Rawson United, Limited, electrical and mechanical engineers, 88, Queen Victoria-street, E.C. The engine is of the single-cylinder vertical type, running at from 200 to 250 revolutions per minute according to the E.M.F. required, with a steam pressure of 150lb., and is provided with an extended bedplate for receiving the dynamo which is coupled direct to the engine, and gives, when running at 250 revolutions per minute, current for 100 16-c.p. lamps, at an E.M.F. of 135 volts, this particular E.M.F. being provided to allow of charging the accumulators. The number of lamps installed throughout the yacht will be about 100, the fittings being of an elaborate description, and designed specially for this installation. The whole of the arrangements are not yet completed, but in all probability there will be provided a set of accumulators, a projector, and also a powerful submarine arc lamp for carrying on scientific observations at night.

Ferranti Mains.—The London County Council have had before them an application from the London Electric Supply Corporation for permission to lay down a main through the yard at the back of the Council's offices for the purpose of connecting the Corporation's station in Red Lion-yard with the main proposed to be laid along Carlton-gardens and St. James's Park to Pimlico. They see no objection to the application being granted on certain conditions, and accordingly recommend that consent be given on following conditions—viz: That a rent of £1 per month be paid for the privilege; that the Electric Corporation do also obtain a license from the Crown to lay down the main; that the main be laid and the work carried out to the satisfaction of the architect and chief engineer of the Council, and on such other conditions as the architect and engineer may think necessary; that the Electric Corporation at its sole cost do make good any damage that may be done to the premises in carrying out the work, and remove the main within two calendar months on receiving notice from the Council; and that an agreement be prepared embodying the foregoing conditions.

The Telephone in Calcutta.—From the report of the Bengal Telephone Company, Limited, for the year ending 31st December, 1890, it appears that, on that date, 437 exchange and private lines were at work, yielding a revenue of 76,400 reals. The improvement of the telephone service is a matter on which great attention has been bestowed, and in Howrah, and to the south of the exchange in Calcutta, faults on the lines are now rare. There is still room for improvement in the centre and north of Calcutta. As extensive repairs and alterations had to be made to the building of the central exchange, the opportunity was taken of entirely reconstructing the switching arrangements. A new derrick has also been erected on the roof, and the exchange is now capable of receiving 800 wires, and these measures, though costly, will be real and permanent improvements. In the last report reference was made to an attempt at opening up business in Cawnpore, but the efforts of the company to induce Government to allow the police stations to be connected, as is the case in Calcutta, Bombay, and Rangoon, have not been successful, and the balance of the Cawnpore account has been written off, as there is now no hope of opening an exchange.

Centrifugal Action.—The effect of centrifugal action in practical work was discussed in a paper before the Institution of Engineers and Shipbuilders in Scotland by Mr. John Laidlaw. Besides calling attention to the necessity for balancing not only flywheels, but pulleys and bevel wheels, the author directed attention to the centrifugal action of belts and ropes in the transmission of power as worthy of consideration. Over and above the power absorbed by communicating a high rate of speed and the continual bending of them as they pass over pulleys, the energy absorbed in overcoming centrifugal action is very considerable. Take the case of a rope 1¼in. diameter, running over 3ft. pulleys at a velocity of 3,000ft. per minute, the centrifugal action amounts to 300lb. per rope. Dynamos which frequently require to be worked in confined spaces could be advantageously driven by direct gearing with greater economy than with systems of belt gearing often adopted. The consideration of the centrifugal action in the belts is one perhaps not often considered seriously. The present use of efficient high-speed engines, driving direct to the shaft of the dynamo would, however, seem to obviate the disadvantages spoken of by the author, whose ideas, nevertheless, deserve attention by all makers of high-speed machinery.

Electric Locomotives for Tunnels.—The example of the Southwark Subway is making its effect felt in numerous proposals, one of the most amusing being that of a correspondent in a Scotch paper, who says that it appears to him that the best mode of preventing smoke in the Glasgow Central Tunnel would be to work the traffic in the tunnel by means of electric locomotives, in the same way as the London subway is worked. Anyone who has travelled on this line must have been gratified with the absence of smoke and steam and the purity of the atmosphere. He would have the Glasgow tunnel purified by the same means. It would not be necessary to disconnect the locomotive, say, in a train coming from Airdrie, all that would be necessary would be to have an electric locomotive standing at College Station to come in behind the train, much in the same way as the assistant engine gets in behind the train at some stations to push it up to the summit of the incline. The electric engine would then push the train and the locomotive through; the steam in the latter being shut off, and there would be no smoke made. Once through the tunnel the locomotive would resume working. The present electric rail now laid for giving light in the tunnel, he says, could be used, and all that is wanted is the electric locomotive to make a trial. The question, however, is not quite so simple as this ingenious correspondent would seem to imagine.

Claybury Asylum.—The London County Council have received a report from the Claybury Sub-Committee to the effect that they have exhaustively considered the question of lighting that asylum by electricity, and are unanimously of opinion that on the grounds of efficiency, safety, convenience, healthiness and cleanliness, electric lighting is the best system that can be adopted, and that it may ultimately prove to be the most economical. A scheme of lighting by electricity has been prepared by Mr. Gunyon, the head assistant of the Council's electric lighting staff, in conjunction with Mr. Hine, the architect of the asylum. This scheme, which has been approved by the Claybury Sub-Committee, contains full details of the proposed lighting and its estimated cost. The initial cost would probably be more than that of gas, say £17,500 as against, say, £15,000. The annual cost would at present be somewhat more, but ultimately less. They remark that this form of lighting the asylum is favourably regarded by the Commissioners in Lunacy, and that it has been in use at the Exeter City Asylum for the last five years with success. It will be desirable to provide gas mains in addition to the electric light, for cooking purposes, and for lighting with gas entrance lodges and main roads, at a cost of, say, £1,000, which amount is already provided for. As it is essential that this question should be settled at once, they have recommended that, subject to an estimate being submitted by the Finance Committee, the necessary steps be authorised to be taken to provide electric lighting at a cost not exceeding £17,500.

Woodhouse and Rawson Staff Lectures.—On February 27th, Mr. T. E. Marsh gave the usual staff lecture, Mr. Stepney Rawson in the chair. The subject of the lecture was "Telephones," and was illustrated most fully by experiments, diagrams, and lantern (oxy-hydrogen) slides. The history of the telephone was traced from the Page effect of 1837 until the present time. The Page effect was easily shown and heard quite distinctly by the audience by means of a large electromagnet, the current being taken off the office circuit. By means of a small motor and a commutator the "makes and breaks" could be made very rapidly, the effect being heightened by altering the direction of the current at each revolution of the commutator. A model of the Reis original transmitter and receiver were shown working, and on a song being hummed into the transmitter in a distant part of the office, the pitch of the voice was reproduced most faithfully on the receiver. When Bell receivers were substituted for the Reis receiver the tune could be heard quite loudly all over the room. The various receivers and transmitters were fully dealt with, and where, for reasons, many of the instruments could not be shown, they were illustrated on the screen by a series of photographic slides, especially taken for the occasion by Mr. Basil Howard. The musical part of the evening was greatly appreciated, a large musical box being laid on to the audience by a number of receivers distributed throughout the room. The singing came out remarkably clear, and a carriage clock in a distant room was heard perfectly at each receiver. The use of carbon in a transmitter was stated to have been the great means of making the telephone commercially successful, the meed of praise being given to Hughes and Edison for this invention. The variation of current, due to a more or less intimacy of contact, was admirably shown by taking two pieces of carbon and including them in the circuit of an incandescent lamp, the variations of pressure corresponding to the fluctuations of the light. In the discussion which ensued Messrs. Stepney Rawson, Broekman, Savill, and Thomas took part, and concluded with a vote of thanks to the lecturer.

University College, Aberystwyth.—The following from the *Cambrian News* shows what electrical work is being done at Aberystwyth University College: "Prof. D. E. Jones, a native of Carmarthenshire, and an old student, is doing good and useful work in connection with the college and education matters generally. A short time ago he drew prominent attention to the disadvantages to provincial colleges of the scheme proposed for remodelling of London University. As hon. secretary to the committee appointed to consider the advisability of giving instruction in agriculture in connection with the institution, he has devoted considerable time and attention to duties pertaining to that office; and recently he has perfected arrangements for introducing the electric lighting into the college. During the past session one of Crossley's "Otto" 7-h.p. gas engines has been obtained, a Crompton dynamo, an arc lamp, and several Sunbeam incandescent lamps. All the fittings have been done by Prof. Jones and Mr. Mitchell. The dynamo is capable of producing, when driven by a 3-h.p. engine, a light of nearly 2,000 c.p. The arc lamp gives a light equal to over 1,000 candles, and the Sunbeam lamps, which are remarkably steady and soft, a light of about 400 candles each. The latter would appear to be particularly suitable for lighting the terrace. Through the efforts of Prof. Jones, the electric machinery, with a lathe, which are of a total value of about £300, have been obtained at a cost to the college of about £30. The machinery will not only be valuable as a nucleus of a school for electrical engineering, but so far as that for the production of the electric light is concerned, particularly interesting to townspeople, seeing that the Corporation intend next session to seek a provisional order to light portions of the town by electricity. It is understood that Prof. Jones is now negotiating for storage batteries which will enable him to store electrical energy and thus avoid working direct from the engine, and being at the mercy, so to speak, of temporary breakdowns. The experience gained at the college will be most valuable when the Corporation set seriously to work to introduce the electric light."

Leamington.—Major Marindin held an enquiry last week at Leamington into the applications made to the Board of Trade by the Corporation and the Midland Electric Light and Power Company for provisional orders to light the town by electricity. Mr. Alfred Young first stated the case for the Corporation, pointing out that they had repeatedly complained of the inefficient manner in which the electric light company lighted the streets. Mr.

W. de Normanville, the borough engineer, was examined at great length as to the defects of the company's installation and the innumerable complaints he had received as to the irregularity of the Parade lighting, which had, he said, sometimes failed altogether. He was of opinion that the defects were largely due to incandescent lamps, which had been adopted by the Corporation on the recommendation of Messrs. Chamberlain and Hookham. The inspector called on Mr. A. Young to submit the details of the scheme proposed to be adopted by the Corporation. Mr. Young admitted that he was not prepared with details, but said the Corporation fully intended to carry out the order if it was obtained. The town clerk expressed his belief that the Corporation would be willing to purchase the company's plant at a fair price. Mr. Hugo Young, in opening the case for the company, urged that the Corporation should only be allowed to have a provisional order if they would buy out the company on the terms to be fixed by a valuer to be appointed by the Board of Trade. The company had spent £30,000 on the plant, at the solicitation of the Corporation. Mr. Arthur Chamberlain was examined in support of the company's application for an order. He contended that the company had fully carried out the terms of their agreement, and that the Corporation had not treated them fairly. The company had increased their charge from 4d. to 8d.; but electricity could not be supplied in Leamington at less than 1s., if it were to be a commercial success. He also asserted that there had been no complaints as to the indoor lighting. Major Marindin intimated that he should make his report in the usual manner to the Board of Trade.

City and South London Extension.—The Bill for the extension of the Southwark Subway has been the occasion of much talk in parliamentary and legal circles on account of the so-called strike of the lawyers, who objected to Mr. Hanbury's ruling that no counsel should cross-examine who had not heard the examination-in-chief. This was compromised by the ruling that if they had heard part of the examination they might go on. Mr. G. Mott, chairman of the company, stated that it was not proposed to make a physical junction at King William-street, so that passengers might be carried direct from Islington to the south of the Thames, as there were serious obstacles in the way of such a junction, one being the enormous outlay in buying the expensive property in King William-street; further, the carriages on the Islington line would be larger than those on the South London line, though the gauge was the same. It had been found that the carriages on the existing line were inconveniently small. Dr. Hopkinson calculated that on an emergency the proposed line would be able to carry 350,000 people a day, and at such rates that it would pay a dock labourer earning 4d. an hour to travel by it. It may be interesting to dwellers on the route to know that in the case of the South London line there has been no claim for compensation on account of vibration, except at the generating station. On Tuesday, the chairman again referred to the incident with reference to cross-examination. Mr. Littler complained that it was an attack on the independence of the Bar, and said he was instructed by his clients (the Metropolitan Railway Company) to state that they were entirely satisfied with the amount of attention given to their interests by their counsel, who were thoroughly acquainted with their history and policy; that the company were not disposed in the interests of economy to instruct further counsel; and that if the committee still refused to hear their present counsel on the grounds stated by the chairman, counsel were instructed to tender their formal protest against what they regarded as a denial of justice and to retire from the room. Counsel for the Metropolitan Company having accordingly retired from the case, evidence was called on behalf of the Corporation of London in opposition to the scheme, and it having been stated that clauses had been agreed upon with the representatives of Lord Rothschild and the Gas Light and Coke Company, Mr. Russell Griffiths addressed the committee on behalf of the Corporation, and Mr. Pembroke Stephens, Q.C., summed up the whole case for the promoters. The committee-room was then cleared, and after a short deliberation in private, the chairman announced that in the opinion of the committee the preamble was not proved. The Bill was therefore thrown out.

Leeds Association of Engineers.—At the meeting of the Leeds Association held last week the president, Mr. Alfred Atkinson, gave an interesting account of his visit to the electric tramway installation at Birmingham, and Mr. Pritchard, the engineer, explained the working of the system. The engines, boilers, and dynamos are in duplicate. Each boiler is capable of generating steam for one engine, each engine delivering 100 h.p. on the flywheel The two boilers are of steel, multitubular, of the economic safety type, 12ft. 6in. long and 7ft. 6in. diameter. The engines are horizontal, of the receiver type, non-condensing, having cylinders 12¾in. and 20in. in diameter, and a stroke of 24in. The dynamos, two in number, are in the same room, each driven with leather-linked belts 16in. wide. The dynamos are of the Elwell-Parker continuous-current type, shunt-wound, each giving 120 volts 500 amperes at an approximate speed of 540 revolutions per minute, and doing the whole of the work of charging the accumulators for 12 cars, and also lighting up the depôt and supplying an eight-unit motor, which drives the machine tools, etc. The cars will carry 50 passengers each, travelling at eight miles an hour. The motors are also of the Elwell-Parker type, running at 140 revolutions per minute, but a velocity of 700 revolutions is required to maintain a travelling speed of eight miles an hour. The visitors journeyed some distance on the cars, which they found to run very steadily, the chief objection being the noise, which might be lessened by more suitable gearing. The overhead system had been passed by in favour of the storage system for the sake of appearance. The latter had, however, the disadvantage of very heavy cars, which came to a gross weight of 10 or 12 tons. Mr. Atkinson then described the wire rope or cable system of tramways, which they next inspected. This system is being worked over a course of three miles, in two sections of 1½ miles each, the engines and boilers, which are also in duplicate, being placed at the lowest point in the gradients, between the two sections. For a distance over three miles, the electrical system, he considered, was doubtless the most economical; but for shorter distances he thought the wire rope or cable system was the best. The overhead method of propelling the cars, as proposed for Leeds, would be cheaper in first cost, and far cheaper in working than the accumulator or storage system; but the under-grooving system was the best of all. Afterwards they visited the works of Messrs. Tangye, where the clean and good castings were especially admired. Mr. Atkinson described the method in use there of distributing and checking the work, which was done by a system of cards, which appeared to take a lot of weight from everyone's shoulders. The delegates were then driven to the house of Mr. George Tangye, which had once been the home of James Watts, and which contains the room in which he used to work, just as he left it. After the Royal Small Arms Factory and various other places of mechanical interest had been described, a vote of thanks to Mr. Atkinson, proposed by Mr. Craister, and seconded by Mr. Lupton, was carried with enthusiasm.

ELECTRIC TRACTION.

II.—ITS APPLICATION TO TRACTIVE PURPOSES.

It has been shown in the first article that not merely in all schemes for employing electric energy for traction purposes, but in every system whatever that uses the electric transmission of power, there are three main parts to consider and so arrange that each one shall prove as efficient as possible.

These constituent parts are:

1. The electric generator, or source of electrical energy, with which may be coupled the necessary boiler and engine or other prime mover.
2. The intermediate conductors or connecting link, which may even take the form of a reservoir of electric energy (as in the case of accumulators or secondary batteries).
3. The electric motor, actuated by means of the electric energy supplied from the generator, either direct through the conductors or indirectly through the medium of storage batteries, and which imparts motion to such machinery as is desired by any accepted method of gearing, direct or otherwise.

Thus far, electric transmission in general. Entering now into more detailed notice of electric traction, it may be said that as regards the first and third of the above-mentioned important and essential parts, nearly all electric traction systems will be found to have common ground of action or the same principles of working. It is mainly in the second essential—that by which the electric energy is conveyed from generator to motor—that there is noticed a fundamental distinction quite sufficient to separate electric traction methods into at least two great systems. The connecting link between generator and motor may be continuous, or it may be broken; based upon this general statement, we can distinguish—first, the *conductor* system; and second, the *accumulator* or *storage battery* system.

These methods employ conveyances which may respectively be spoken of rather more in detail, as follows:

1. Vehicles, or cars, driven by electric motors which receive their supply of energy from a central station by means of metallic conductors fixed on the route of travel, connected to generator dynamos at the central station, and with appliances for a rolling or sliding contact between the car motor and the fixed conductor conveying the current.
2. Vehicles driven by electric motors which receive their supply of energy from storage batteries, periodically re-charged at the central station, and carried by the vehicles themselves, or by small "dummy" cars with the electric motors attached.

Taking these in the reverse order, we may first consider briefly the

Battery System—As presenting the fewest complications or possible subdivisions in applying it to actual use.

"Looked at from the standpoint of *convenience* and *applicability*," say Wetzler and Martin, "the propulsion of tramcars through the medium of accumulators must be conceded to be second to no other. The batteries occupy no valuable space, being stowed under the seats, while the motor can be placed under the car body. Adding to this the absence of smoke, dust, escaping steam, and its accompanying noise, it becomes manifest that the points in favour of such a system are of a most decided nature."

The chief objections brought forward against the use of accumulators for traction purposes are two in number. In the first place, their excessive weight forms a serious item in considering the total expenditure of power that is necessary on any given line; and secondly, their employment brings in at least two additional transformations of energy with an attendant small loss at each change.

This latter point will be appreciated more closely if the actual steps are given. Thus we have first the mechanical energy of the steam engine or prime mover transformed, as we have already seen, into the electrical energy of the dynamo generator.

This latter is, in the second place, transformed into the chemical energy of the accumulator, and kept in this form *as long as required*, until it is used up or again changed by *reconversion into electrical energy*, and in the latter guise employed in the electric motor to give mechanical work on the motor spindle.

Starting from the dynamo generator, these several transformations may be tabulated thus:

Generator yields electrical energy for inducing in the *accumulator* a state of chemical tension, which continues after connection with the generator is cut off. This tension on release at once gives rise to electric energy, which can be used in the *motor* to do mechanical work by means of a rotary motion.

This may appear to be a somewhat roundabout method of applying the power originally available, especially after what has been already pointed out respecting the possible losses of energy, in using electricity as a motive power; but owing to the comparatively high efficiencies obtained at each conversion or change in the form of energy, it is possible to operate electric accumulator tramcars almost as cheaply as by means of horse power or even steam locomotion.

"It is boldly asserted that by using efficient apparatus and economical arrangement, these losses are reduced to a point below that experienced with other systems, with the gain of many off-setting advantages."

The highest efficiency claimed for an electrical accumulator is 82 per cent., whilst the actual efficiency stated by competent authorities to have been obtained in practice is about 70 per cent. There is, however, a considerable field for improvement in the construction and design of storage batteries, so that the efficiency mentioned above is almost certain to be generally assured as time goes on and experience dictates alterations in detail.

Even as it is, however, the efficiency is quite high enough, especially in comparison with other methods, to warrant the use of storage batteries for tractive purposes, when their many advantages are considered. These may be summed up as follows:

1. The cars can run on any track already laid down. No alterations require to be made on modern tram or rail roads to adapt them for the electric accumulator cars.
2. No wires or metallic conductors are required, either overhead or underground, to convey the current from dynamo generator to the electric motors. As regards overhead wires, it will be seen that a cheaply-erected, but unsightly, system is thereby avoided; but more will be said concerning this further on.
3. Each car is quite independent of the other. This quality is peculiar to battery cars, and its importance must be admitted at once. In other systems, where the necessary current of electric energy is derived by the cars from the line of travel, any possible breakdown in the central station supply would mean that traffic generally along the line would be stopped completely until repairs should be made and the supply resumed.

With accumulator cars, however, carrying their own supply of energy, there is absolute independence of one another and of the central station so long as the supply lasts. This will be for half a working day at least—each set of accumulators, as a rule, being capable of operating the car for that length of time—thus giving an opportunity for repairs in case anything goes wrong at the charging station.

A final advantage of the battery system lies in the fact that the charging station may be placed anywhere along the line in the position best suited for its economical erection and efficient working; considerations of cheap land and nearness of coal supply can be of paramount interest when there is no necessity for the electric power supply station to be situated either at the centre of the line or at either end. When a choice of station sites thus becomes possible, a great economy can be effected on the first cost of the entire line.

Of course the batteries—which practically represent the horses of an ordinary street car—will, when drawn upon, only yield their power for a certain length of time dependent upon their size; and just as horses require long periods of time for food and rest, so accumulators are found to need recharging after they have done a certain amount of work. Arrangements are therefore made—in the case of a car which carries its own storage supply—for the batteries to be very rapidly shipped and unshipped, so that after completing the proper number of runs for a total distance of, say, 60 or 70 car miles, the car may be taken to the central station (where the accumulators are charged), and may there have the exhausted batteries taken out, fresh ones, fully charged, being put on board in their place.

The whole process occupies little (if any) more time than is necessary for stablemen to change the horses in an ordinary car; whilst it becomes a matter of still greater simplicity when separate "dummy" cars or small locomotives are used for the batteries and motor. All that has to be done in such a case is simply to detach the "electric engine" (if it may be so called) with exhausted batteries, shunt it upon another line ready to be recharged, whilst the new one with the cells replenished is run up to the car for its next series of journeys.

The various applications and conditions for which this battery system proves more especially suited will be considered later on, when the different types of electric roads come up for treatment. A brief description only of the method—such as that given above—is required at this point.

The second of the two great systems of electric traction has been spoken of as the

"Continuous Conductor" Method,

and regarding this a slightly more detailed notice will be necessary by reason of its greater complications and varieties.

These different forms may be, perhaps, most readily classified according to the disposition of the conductor, which, after all, is the essential feature. Thus we may have it embedded in a conduit or trench below the ground level, or it may be fixed on the surface of the earth in the shape of a third rail or light continuous conductor, on which runs a special contact wheel attached to the car; or, lastly, the conductor may be placed overhead considerably above the ground level.

There are, then, three chief types of the continuous conductor system of electric traction. I. Overhead. II. Surface. III. Underground.

I. *Overhead Method.*—In this case the usual plan is to employ a conductor of stout wire, suspended from brackets fixed to poles that are either erected at the sides of the road or street, or else placed in the centre between the tracks.

Another way of supporting the conductors is to erect poles along the street or road, at each side opposite one another; cross-wires are then strung over the street between the poles, and the conductor hangs from the cross-wires.

In all these cases the cars run on the ordinary tracks, and the conductor is used to convey the current alone; this point differentiates the overhead conductor system for ordinary tramways from telpher lines, inasmuch, as in the latter, the overhead or aerial wire or rail serves to convey the vehicles employed, as well as the current of electrical energy required to drive them.

When poles for overhead wires are erected in the centre of the road or street, they are placed about 125ft. apart; from actual experience they are found to present little or no obstruction to the traffic. This would follow from the fact that along tramway routes there is not, as a rule, very rapid traffic; it is characterised rather by a slow, continuous, and heavy nature. There is a further advantage to be derived from the use of an overhead system: the same poles when properly erected will serve to carry the electric lamps for public lighting of streets and roads.

The conductor wire may be single or double; when the former plan is adopted, the rails are employed for the return or negative main from the motor.

When two wires are used, of course one wire carries the outgoing current, and the other serves as the return.

Contact between the car and conductor is obtained by means of a small trolley or light carriage running either upon the wire or underneath it. The overrunning trolley has one or more wheels resting on the wire, a flexible connecting wire being used to carry the current down from conductor to car and motor. The trolley is pulled along by the flexible wire.

There are some serious objections to this plan, however, of using an overrunning trolley. It is sometimes a difficult matter to keep the trolley on the wire. When it does come off there is more difficulty in getting it on again; whilst, lastly, it becomes almost impossible to manage a switch or siding with success.

In the underrunning trolley a light arm or rod of the proper length is fixed in a swivel on the top of the car, reaching up to the wire. A wheel on the end of the arm is pressed up against the wire by means of springs at the other end, the current traversing the wheel and arm down to the car and then to the motor. The trolley arm is constructed to swivel round to the entire circle, whilst it can also bend up or down from a vertical to a horizontal position.

II. *Surface Method.*—There is sometimes considerable advantage to be gained, in point of initial outlay, by placing the conductor on or near the ground level. Of course it must necessarily be well insulated, not only from the ground but also from the track rails, if these are used for the return current, as would generally be the case.

As already remarked, the adoption of such a plan effects a great saving on the first cost of the line, it being admittedly less expensive to lay a third rail forming the conductor alongside or between the track rails than to erect poles with overhead wires; besides which, the workmen can more easily attend to the necessary repairs from time to time.

There is, however, an evident drawback in the fact that such a method is quite unsuited to streets or open roads, although it might possibly be of service on an enclosed line where trespassers become the exception rather than the rule. Considerable danger to horses and individuals might ensue if a high potential or electric pressure were rendered necessary for due economy of working, whilst still greater difficulty would be experienced on the score of insulation. Every wet day might mean a serious loss of power through leakage along the line.

This system is not therefore at all likely to come into extensive use except, in a few special instances, where the tracks are fenced in from the public, or are, at any rate, not immediately accessible; where the conductor rail may be kept well insulated from the other rails and from the ground, and where electric power can be obtained at a very small cost, by means of waterwheels, for instance, erected at a neighbouring fall.

III. *Underground Conduit Method.*—For many reasons this plan would appear to be the best and most readily adopted of all the continuous conductor methods, so far as concerns the more crowded streets and thoroughfares, where overhead wires are unsightly and inconvenient, where a third rail is impossible, and storage batteries inefficient or wasteful.

There is no great disfigurement of the streets, and no more inconvenience to other vehicles than is the case with ordinary tram lines, still less than with cable trams, inasmuch as the necessary slot for the flexible connection between conduit and car motor can form the groove usually found in the rail employed for tramways.

The prime cost of such a system is, however, very great, and some amount of difficulty is certain to ensue with regard to insulation, unless the line is well looked after and carefully maintained.

As usually constructed, this system comprises a strong solidly-built conduit or trench underground, lined with cement and well drained. A narrow slot allows of a flexible connection entering the conduit to lead up the current from the conductor to the car motor, a small trolley or travelling carriage being employed to obtain the necessary rubbing or sliding contact along the conductor.

The conduit itself may preferably be placed just underneath either of the track rails, in which case the latter would form part of its walls, and, as has already been said, the conduit slot would serve as the rail groove in which the car wheel tyres usually run. There are then only the two grooves or openings—viz., one ordinary rail and the conduit slot—a point of some importance along roads where there is much traffic.

Briefly reviewing these three continuous conductor methods, it will be seen already—and will be shown to be so in still greater detail further on—that each one has its special uses and advantages, and that for varying conditions it may be considered best to adopt any one of the three. Thus, considering the matter as regards tramway work alone—for isolated country roads where there is not much ordinary traffic there can be no hesitation as to choosing the overhead conductor system. For crowded city streets the battery car must almost inevitably take the palm, if only on account of its independence; its avoiding such inconvenient affairs in the street as overhead wires or conduit slots; and thirdly, the small amount of room it takes up.

Then, again, in the less crowded suburban roads the conduit system would have many advantages, especially where gradients are heavy and curves numerous. It is almost impossible to say that any one of these systems is the best under all circumstances: each is good in its way, and we shall further on see more generally what methods are particularly suitable to the various kinds of lines or ways on which locomotion is desired.

(To be continued.)

ELECTRICAL EXHIBITION AT ST. PANCRAS.

The local electrical exhibition organised by the Vestry of St. Pancras is a very pretty and very successful affair. The initiative is, we believe, due to the energies of Mr. Eccleston Gibb, who has evidently succeeded in embuing at any rate many of his co-workers with the enthusiasm for electricity, and this exhibition should be the means of introducing many lovely, novel, and useful appliances into the houses and shops of St. Pancras.

The exhibition was opened in grand state on Monday by the Lord Mayor, accompanied by the sheriffs, and on Tuesday, when we visited it, everything was in spick and span order. It is held in the Vestry Hall, St. Pancras, about 10 minutes by tram from King's Cross Station. The hall and side rooms are very tastefully decorated with hangings, ferns, and palms, amongst which the electric lamps gleam and glitter, and really handsome fittings abound on all hands. Some of the rooms are furnished as living-rooms, and the whole exhibition is laid out to give just the kind of information and effect as those who wish to introduce the electric light would appreciate. It is not too large to comfortably go through in an evening and yet to see nearly everything, and altogether is an admirable example of what may be done to extend the use of electricity by small local exhibitions. There are about 30 stalls, all tastefully decorated and laid out.

The engineering part of the work was undertaken by Messrs. Sharp and Kent, comprising a Willans 80-h.p. engine and a 20-h.p. turbo-generator, 100-h.p. Gainsborough boiler, a feed-water heater, Worthington pump, and Goolden dynamos. Messrs. Johnson and Phillips exhibit in the street, in front of the entrance, a Brockie-Pell arc lamp suitable for street lighting, giving a perfectly steady and brilliant light that is much admired.

The stands inside the exhibition are numbered consecutively 1 to 30. A stand at the entrance not included, which we may call No. 0, is that of Messrs. A. Emanuel and Son, of Marylebone-lane and Euston-road, who exhibit a collection of switches, ceiling roses, and bellwork, with main switches in locked boxes and a number of electric brackets. Mr. Harry Thorpe, 59, Theobald's-road (Stand 1), is the maker of tubular switches and fittings in brass, nickel, and bronze. Messrs. Engelbert show samples of their well-known lubricating oils.

At Messrs. Miller and Woods (Stand 3) can be seen a working specimen of Chamberlain and Hookham's electric meter, of which some 400 are at work in Liverpool. It is a 10-light meter, starting to indicate with one lamp only, and acts by the motion of a series disc armature rotating in a retarding field of a permanent magnet. A number of very useful fittings are shown, more particularly a neat up and down pendant, which has a large hollow knob part way up the flexible cord, containing a lead differential wheel. Another embodies the use of flexible tubing for pendants for a staircase or similar situation. Miller and Wood's latest type of ammeters and voltmeters are shown. An interesting item is a specimen of the new Oerlikon arc lamp, for which this firm are agents. This lamp is remarkable as being the only lamp, so far as we are aware, that can be directly connected in parallel to a 50-volt circuit—say to 25 accumulators—without resistance. The regulation is effected by a double-acting arm, which both turns a friction wheel and acts as break, having a continual upward tendency.

Messrs. Latimer Clark, Muirhead, and Co., at Stand 4, have a very fine case of instruments, amongst which their galvanometers in many types are conspicuous. Blackburn's portable testing set, comprising in one pocket-case all the delicate instruments wanted for ordinary testing, from ·005 to 2,000 ohms, is a noticeable exhibit. They have specimens of very well-designed house main switches and fuses as used on the St. James's circuits, and full-sized examples of the bare copper mains and junction-boxes as used in that system are particularly interesting at this juncture. A Westminster dynamo (for 60 16-c.p. lamps or as 5-h.p. motor) is shown.

We next come to an extremely artistic exhibit (No. 5) from Messrs. Benham and Froude, Chandos-street. Here are electroliers and standards in profusion, delicately covered and draped; sconces with green plush backs, and chased gilt brasswork with green-gold silk shades suitable for a lady's boudoir; a sample of the brackets supplied to the Lyric Theatre, the fittings for which this firm specially designed; a very pretty table lamp, one of 300 supplied to the Hotel Metropole, Brighton, bronze and silver plated; tall standards for raising and lowering, one for a reading lamp for standing behind an easy-chair; and many little fancies in colour and silk.

The Acme Electric Works (No. 6) have perhaps one of the most interesting stands for those who are wishing to buy electrical fittings. They have a large stand filled with well-made and well-designed pieces of apparatus. Their most novel and interesting exhibit is a new meter, which has been just brought out by Mr. Teague, the present manager—a very ingenious and apparently quite successful instrument. It consists of a solid electromagnet in the shape of a quadrangle of soft iron, one of the poles being made to project up inside a hole bored in the other leg of the magnet; in the space between the two is hung a thin plated tube of copper, which revolves by the well-known disc effect of Faraday; the magnet is wound with a coil of fine wire and one thick series turn, and the copper tube being worm-geared to a train of wheels has the advantage of being made to register in direct units. It has another also—that if a 20 or a 100 or even a 500-ampere meter is desired, all that is necessary is a larger rotating tube and a larger series coil on the magnet. The price is moderate—£6 or £7—and the Pall Mall Company are now testing this meter, of which we venture to predict more will be heard. Improved quick-brake switches of best workmanship, Cockburn's cut-outs, house main switches as adopted in the Pall Mall Company, Ayrton and Perry volt and ammeters, ornamental roses, switches, and wall sockets, make up a most interesting show. An A. and P. instrument, to measure either amperes or volts with the same needle, is handy for testing, and similar instruments are also made with the two dials side by side in one box.

The next stand, that of Mr. F. Geere Howard, shows a handsome assortment of pendants, switches, and accessories, wood casings, shop window specialities. Messrs. Illingworth Bros., of 22, Ganton-street, W., show fittings for private residences.

The General Electric Company are to the fore as usual with any amount of varied fittings, glass, brass, porcelain; Aron meters in great number; registering ampere and voltmeters giving blue curves like the well-known registering barometers. They have several motors driving fans and pumps; and a special side-show of electric water boilers, hair curlers, flat-iron heaters, and so forth, which are the object of much admiration from the ladies. Heaps of flexible wires, numbers of electroliers of all kinds, and many types of magneto telephones for housework show what can be done for widening the application of electricity at home. Around one corner the same company have a special room for the exhibition of the Berliner gramophone, which can be heard at odd intervals spluttering and croaking away as a cornet player, or a reciter of "Twinkle, Twinkle, Little Star," and other pieces.

A smoke-consuming hollow fire-bar, to admit and heat the air, is shown by Messrs. Caddy and Co., of 33, Pentonville-road. Messrs. Babcock and Wilcox show a model of their celebrated water-tube safety boiler, so largely used in electric light installations.

One of the real novelties of the exhibition is exhibited by Messrs. Rashleigh, Phipps, and Dawson, of Berner's-street (Stand No. 11), in the shape of a very pretty little addition to the Edison and Swan lamp. This is a little curtain or bag made up of glass beads, which tightly encloses the incandescent lamp, and the effect is exceedingly pretty. The light is broken up and diffused, and the bare lamp is transformed into a beautiful sparkle. This "bead ray-diffuser," as it is termed, is applied to many very artistic fittings with great effect. Below this stand Messrs. S. Z. de Ferranti (No. 13) have a large number of the Ferranti electric meters in simple metal cases, looking the very thing that a meter should be. We have lately described this meter, and, as is known, there is only one moving part in the interior besides the wheels: all is enclosed and inaccessible; the meter being, in fact, a small alternating-current motor of simplest form, and does not require winding up or calibration. Messrs. Arthur Gill and Co. (Stand 14), of Parliament-street, have an interesting exhibit in a room to themselves, showing a large selection of fittings, holders, shades of ornamental character, a new arc lamp, electric motors of their own make, which are applied to useful work, besides various kinds of instruments, portable lamps, telephones, and fire alarms.

Besides their work below in the machine-room, Messrs. Sharp and Kent, Victoria-street (No. 15), show artistic electric fittings, silver-plated table lamps, and a set of instruments as supplied to the Brighton Corporation. Messrs. F. and C. Osler, Oxford-street, have one of the most tasteful displays in the hall. Specimens of their lovely cut-glass are, of course, present in alluring profusion, but the palm is awarded to some beautifully modelled and tinted figures in Worcester china bearing lamps—none more handsome could be designed. Messrs. Crittall and Co., 20, Baker-street, have a large show of metal work, electroliers, lanterns, and pendants in wrought brass, cast and chased, and wrought iron and steel of many patterns, a large part of their business being with the trade.

For those who require installations throughout, the stand (No. 18) of Messrs. Drake and Gorham, Princes-mansions, Westminster, offers many attractions. Here are samples of the improved unpasted storage battery, heavy switches for the proper distribution of currents in engine-room and house; Cardew patent voltmeters and earthing devices; a variety of accessories, china switches and roses, of which the firm have many very desirable patterns; and specially a splendid show of Powell's tinted glass work, for which Messrs. Drake and Gorham have been appointed agents. The National Telephone Company have connected telephones to the Royalty Theatre, Manchester, and the Savoy Theatre, by which an impromptu attendance at "The Gondoliers" can be enjoyed. The Sunbeam Lamp Company, of Gateshead (No. 19), have a full set of their powerful incandescent lamps and necessary fittings. In the way of carbons, Messrs. Lacombe and Co. (No. 20) show every imaginable variety.

Passing on, we next come into an extremely handsome room furnished as a library, and filled with the electrical productions of Messrs. Woodhouse and Rawson. A luxurious sofa is lighted for reading by their brackets; the centre of the room is lighted by the improved (Boardman) "Sun" lamp, the incandescent arc of which sheds a warm glow around. This lamp now is being made by Messrs. Woodhouse and Rawson, and the automatic feed seems to act well. Jensen bells tinkle in one corner; magnetic cut-outs guard the mains in another. Ammeters, voltmeters, switches, and fuses cover the table in liberal profusion, while in the cases where books ought to be instruments of every variety gleam in brass and ebonite. In an inner room we come to the Keys' Electric Company, who have a handsome exhibit, including their dynamos, motors, arc lamps, with instruments, galvanometers, switches, and fuses of a solid type. They have a number of small electromotors applied to household purposes, washing and wringing machines—a feature for which this St. Pancras exhibition is altogether specially noteworthy. Messrs. Strode and Co., 48, Osnaburgh-street (Stand 23), are another firm who have a most artistic set of electroliers and standards, shaded with silk, lace, and gauze. A large wrought brass pendant of 14 lights, for saloon or public hall, has been specially admired, and the same with large dome pendant on rose-coloured silk for a mansion dining-room. There is also here shown a "Taunton" dynamo, well built, and ingeniously fitted with brush regulation. A little switch for house installation is particularly interesting (Strode and Gill's patent), having a solid porcelain base and two stout brass horns, which are depressed by the turning over of a knob, making contact in a firm and efficient manner.

A large double stand fitted with a variety of apparatus (No. 24) is that of Messrs. Paterson and Cooper. A Phœnix arc lamp, as used at Peter Robinson's, plays a principal part; a very complete set of ship fittings illustrate this branch of electric light work. They have also a good show of glass, and a very pretty reflector for shop windows to obviate the dead black usually seen, is made of plated metal pierced with a number of pinholes in a pattern, through which the light gleams without detracting from its reflecting qualities. The new combination telephones are shown in working order. A large and very handsome gold and pink electrolier in wrought metal of elaborate design attracts much attention, while a really most beautiful spray of three vine leaves in silver mounted on a dark plush ground is one of the best fittings in the exhibition. Motors, dynamos, porcelain fittings, and Paterson and Cooper instruments make up a most interesting exhibit. In another room across the stairs, Messrs. Joel and Co., Wilson-street, Finsbury (No. 26), illustrate plant necessary in the erection of installations—Joel dynamos, accumulators, switchboards for complete installations and supply companies, a practical primary battery for doctors' use, double-pole fuses, holders, and so forth. A photographic arc light on a stand is shown, 6,000 c.p. to 20,000 c.p. The most novel exhibit is, however, a new motor, never before exhibited, which will doubtless be in large demand. This motor is made up of stamped iron plates in a very neat and scientific pattern, and can, as there is no shaping, be made at an extremely low cost. It was seen driving a pneumatic despatch tube. The small size shown will give $\frac{1}{2}$ h.p., and is one of the most interesting exhibits in the exhibition. Messrs. T. Potter and Son, South Molton-street, show in the same room many very handsome pendants, and electroliers in iron, copper, and brass, of elaborate design, of which a church eagle lectern with electric brackets is specially noticeable.

The last three stands are of the most important in the exhibition, being placed down the centre of the large hall. That of Mr. Conolly, of Hampstead-road (No. 28), faces the visitor as he comes in, and consists of a large and varied assortment of artistic fittings, brackets, pendants and shades, and the hundred-and-one accessories which will be in large request in the district. The next stand, the chief and largest in the exhibition, is that of the General Electric Traction and Power Company. Here we see small motors ($\frac{1}{4}$, $\frac{1}{2}$, and 2 h.p.) applied to all sorts of useful work; fans for ventilating are well known; we have also churning, washing and wringing machines merrily spinning to the great delight of visitors; a mechanical drill, driven by $\frac{1}{2}$-h.p. motor, drilling 1in. holes in steel or iron; resistance frames for their regulation, motor switches, as used on launch and tram work, and assortments of many other switches and apparatus. The last of these centre stands—a particularly handsome and tasteful one—is that of the Planet Electrical Engineering Company, of Victoria-mansions, and 67, Piccadilly. Here are the Planet motor arc lamps at work, or to be inspected internally. A 40-ampere photographic arc lamp is arranged on a convenient stand; a number of portable spring ammeters for hand or ship use are interesting, special lock-up switches for house mains, with ingenious cam action, are applicable to central station work. In this stand are a number of very handsome wrought-iron electric fittings, which the firm make a special part of their trade, curled spirals and springing leaves, artistically intertwined to carry the little electric globes which shine through the waving leaves of the palm trees and ferns with which the stand is decorated.

We have said enough to show that if the exhibition is small it is eminently interesting, and, indeed, just the sort of exhibition to interest local residents, and, best of all, to bring in many orders to those who have taken part therein.

THE PARIS-LONDON TELEPHONE LINE.

The telephone line from London to Paris has at last been connected between the two capitals, with the most distinct success to reward the long calculations, experiments, tests, and struggle with practical difficulties, which Mr. Preece and his able coadjutors have undertaken. It will be remembered that on Monday last week the cable was paid out in the midst of the tremendous blizzard. The end was buoyed to avoid cutting the cable, and the "Monarch" ran for the Downs. The next morning the sea was lashed into foam by the easterly gale, and on Wednesday it was not much better. Thursday was fine, and the "Monarch" proceeded to pick up the cable and to clear it from an anchor lost in the gale. This was done, and the anchor recovered and the end of the cable buoyed. Friday was again very rough, but on Saturday the "Monarch" was successful in picking up five miles and relaying it to clear the Calais-Dover telegraph cable, and landed the other end at St. Margaret's Bay. The end was brought into the cable-hut at quarter past six, and the news was telephoned through with cheers to the Post Office. The rasping of the file baring the end could be distinctly heard in London. It only remained to test and join up the cable, but care was taken that no one should speak right through from London to Paris before the French authorities, as a compliment to them. The line was spoken through on Wednesday, the following account of the ceremony being abstracted from Thursday's *Times*:

Yesterday morning the establishment of telephonic communication between London and Paris was inaugurated. Our Paris correspondent informs us that the first message transmitted was one from the Prince of Wales to M. Carnot. An exchange of congratulations then passed between Mr. Raikes, Postmaster-General, and M. Jules Roche, Minister of Commerce, Industries, the Colonies, and Posts and Telegraphs. At the Paris Central Telegraph Station, Lord Lytton, Mme. Roche, M. Reinach, M. Broquisse, and M. de Selves were present with M. Roche. Mr. Raikes spoke from his room at the Post Office. The Ader apparatus was employed. At a quarter to 12 Mr. Raikes spoke, and M. Roche replied.

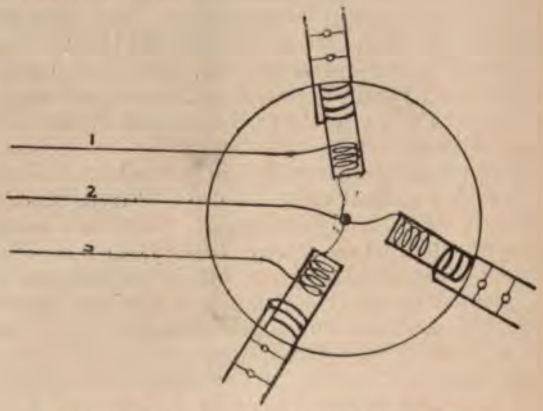
In the afternoon the line was thrown open to representatives of the Press, who, under the direction of Mr. Chambre, availed themselves of the opportunity to converse with the English electricians, Messrs. Kempe and Brown, at the other end, Mr. Melton Prior discovering a friend there whom he had not seen or spoken to for 14 years. One and all were surprised at the clearness of the speech, which appeared to come from an adjoining room, some averring that it was better than could be heard on the ordinary exchanges of this country.

These trials are not absolutely the first which have taken place. On Sunday evening last, at 5.40 p.m., the cable was spoken through from the cable-hut at St. Margaret's Bay, near Dover, all the way to Paris. M. Amiot, the Inspector-General of French Telegraphs, was the first person to speak. Lieut. O'Meara, R.E., followed, and was therefore the first Englishman to speak across the Channel. On Tuesday afternoon M. Amiot, who had proceeded to London, also opened up the communication between London to Paris. At 4.15 p.m., he addressed his colleagues in Paris, his first words being "Hallo, hallo!" which is now the universal telephone call. The Gower-Bell apparatus was that employed. Prof. Hughes, the discoverer of the microphone, Mr. Graves, Mr. Preece, and others, afterwards spoke through the line.

The apparatus is arranged for speaking in Room 90 of the Post Office, the instruments being fixed against the wall on a board covered with red cloth, inscribed "Paris-London," and decorated with the Tricolour and Union Jack. The chief transmitters pitted against each other are the Gower-Bell, the Hunnings, the Berliner, the Ader, d'Arsonval, and Roulez. So far the Post Office form of the Gower-Bell appears to excel the others, but it would be premature to express a final opinion on the subject. The Ader seems to be best of the French apparatus for this work. Perhaps the Gower-Bell will be used at this end of the line, and the Ader at the Paris end. It is the Ader which is used in our military camps, but the Hunnings is used with an army in the field. A simple device of Mr. Chapman's has been mounted beside the instruments in the Post Office to mark the periods of three minutes allotted to a conversation. It is a small box containing a wheelwork which is controlled by a standard clock. At the end of every three minutes the wheelwork makes a contact, and sends an electric current which rings a bell. The attendant then stops conversation by cutting the telephones out of circuit. A small clock will, perhaps, be added to give the speaker some idea how his allotted time is flying. It is probable that the line will be open to the public in about 10 days or a fortnight.

THREE-WIRE ALTERNATE CURRENT DISTRIBUTION.

The announcement by Mr. Gisbert Kapp, at the Cantor Lectures, of the intended installation of three-wire alternate current transmission at the Oerlikon Works, has given rise naturally to considerable speculation upon the possibilities of this method, and enquiries as to the ownership of the patent of the dynamo.



Three-Wire Alternate Current Transformer.

It seems that an American patent was taken out some years ago, by Charles Bradley, for the rotating phase alternate-current motor, but no English patent has been granted. It rather appears, therefore, as if this important development were given to us free. We believe one of the motors is being closely tested, and the results will be regarded with great interest.

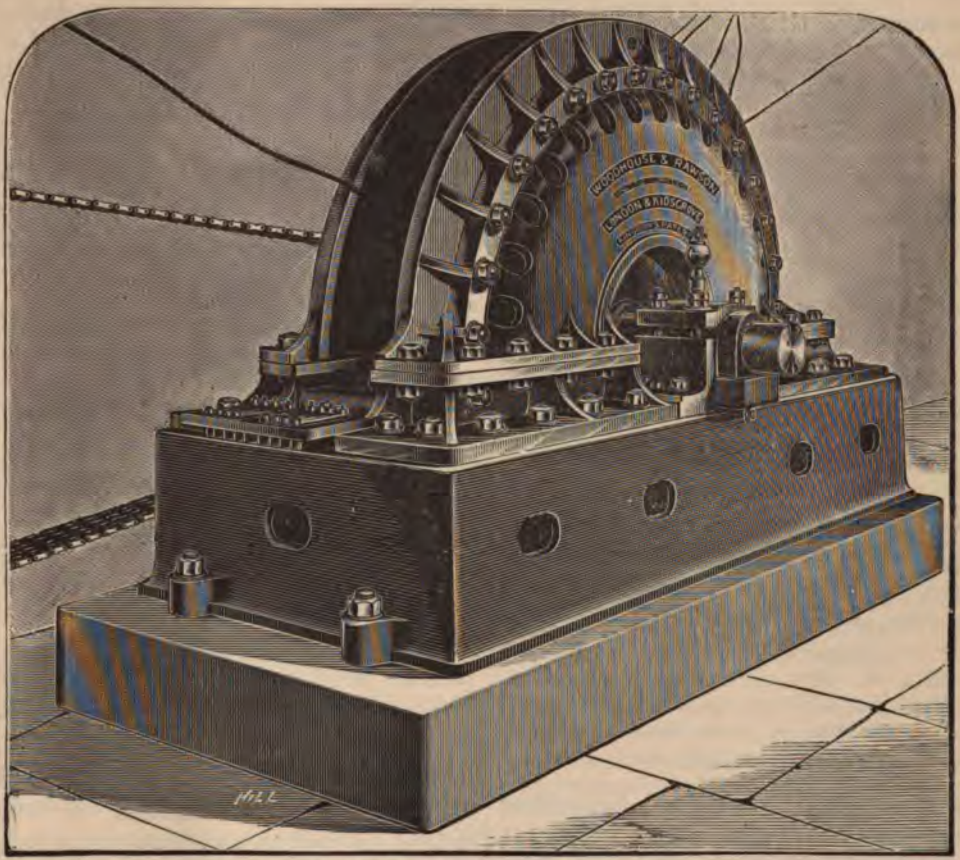
With reference to the possibility of lighting at the same time as transmitting power, there does not seem to be any difficulty about this.

We give herewith a rough diagram of the three-legged transformer that is used to reduce these three-phase currents. From this it will be seen that ordinary parallel distribution is perfectly easy. The three-pole motor is inserted either in the primary or with transformers, if the primary is very high. The wires are technically known as +, 0, and −, but this is a mere convention, as the phase is continually following round the three wires. In the transformer, one end of each primary is connected to the primary wires, and the other end of the transformer primaries are connected together. The secondaries are distinct and act like an ordinary alternate two-wire circuit if connected up as shown, or they can be connected together to drive the alternate-current motor.

An interesting fact is that the ordinary Thomson-Houston three-pole dynamo, if concentric rings are placed on the axle instead of the ordinary commutator, will run as one of these motors.

THE KINGDON INDUCTOR DYNAMO.

Our illustration represents a 70-unit alternating-current dynamo designed by Mr. J. A. Kingdon for central station work, and used by Messrs. Woodhouse and Rawson for lighting their engineering works at Kidsgrove, Staffs. In this machine the coils, which correspond both to the armature coils and to the field magnet coils of an ordinary alternating-current dynamo, are fixed, while the revolving wheel carries a number of laminated masses of iron or inductors, which produce by their motion magnetic changes in the iron cores of the armature or secondary coils.



The Kingdon Inductor Dynamo.

The magnets of the dynamo are built up of a number of stamped iron plates, and bolted between two stout circular cast-iron frames divided horizontally along the centre line. The lower frames are bolted to a stout cast-iron bed-plate.

The inductor wheel is of exceptionally strong mechanical construction, and consists of 16 inductors, which are constructed of a number of soft iron plates, insulated from one another and bolted between two stout steel plates mounted on a hub keyed on to the main driving shaft. Between the inductors and steel plates are two brass rings, which magnetically insulate the inductors from one another. The field magnet or primary poles are permanently magnetised with the polarities indicated by the current from a small exciter. The intermediate poles have their polarities constantly changed as the inductor wheel rotates, and alternating currents are accordingly generated in the coils with which they are wound.

There are no brushes or rubbing contacts, all the coils being fixed. The dynamo in use at Kidsgrove is wound with one set of coils for supplying incandescent lamps direct at 105 volts; and another set is wound with high-potential coils for transformer circuits, while a third is used for arc lamps.

Two machines of similar, though slightly different design, have been supplied by the company and erected at the Woking central station. These are wound for 30 amperes at 2,000 volts, and are coupled direct to triple expansion engines, which were also manufactured by Messrs. Woodhouse and Rawson United, Limited, at Kidsgrove.

CORRESPONDENCE.

OVERHEAD WIRES.

To the Editor of the Electrical Engineer.

Sir,—I am much obliged for your criticism of my report on overhead wires, etc., and admit at once the force of much of what you say, but it must be borne in mind that my report had special reference to Chelsea. Of course in the City, where the main lines of wires are practically permanent, it would no doubt be a great advantage and more economical to lay wires underground perhaps by the Brooks system, though you do not give any idea of its cost; but in an outlying district like Chelsea, where the subscribers to the telephone are not very numerous, it would not probably be worth the expense for any company or person to lay down pipes on the chance of the line becoming permanent. The telephones in the City are fixed to offices and are almost a necessity, so that they in all probability would remain in use should the present occupier of the offices remove, but in Chelsea they are a luxury, and the chances would be 100 to 1 that the next resident would require a telephone were the occupier now using it to leave.—Yours, etc.,

T. W. E. Higgens, A.M.I.C.E.,
Surveyor to the Vestry.

Chelsea, 16th March, 1891.

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DEPTFORD.

Is it not singular to find how completely the mugwumps have alighted on the side of the fence in praise of Mr. Ferranti? It is not so very long ago since most technologists shook their heads and expressed doubts as to the possibility of this young engineer carrying out his promise. Rashness exemplified, speculation, utter failure, were terms frequently used in connection with the new departure. Here and there a voice was heard hoping Mr. Ferranti's plans would succeed, because he showed so great an amount of pluck and energy. A fire occurred—another fire—and jubilant enemies uttered the always-to-be-remembered "I told you so," but, unfortunately for them, Mr. Ferranti's prophecies have proved correct, and his hitherto revilers are rapidly turning round with congratulations. It is perhaps just as well that the world's memory should be no longer than nine days, otherwise the weathercocks would not be tolerated. We have said before, and it will bear repeating, that hardly a single electrical engineer was found to be ready to strengthen the hands of the worker at a time when his troubles were greatest and his difficulties almost insuperable. Many unjust criticisms were hurled at his head, and not the least was the openly expressed opinions that his gigantic scheme was from the first an unsubstantial dream—not thought out, and against the teachings of science; that in some peculiar manner he had got men of wealth to believe in him, and was spending huge sums of money in the most reckless and haphazard manner, all of which must surely be lost. What is the position of these critics to-day? They have done their worst. They have to a certain extent gained the ear of the public, and beaten down the quotation for the shares of the company far below their real value. What is the present position of affairs? Mr. Ferranti tells us in his report, given in our last issue, also Mr. Forbes in his speech at the meeting of the company, given elsewhere. The whole report and the whole speech show no indications of failure, but may, indeed, be said to be pæans of triumph. The mains have been laid, the engines and dynamos are being run, current under a pressure of 10,000 volts is being transmitted from Deptford to light some 10,000 lamps, and within three months the machinery will be ready to supply 90,000 lamps. Certainly, large sums of money have been expended. It was intended that large sums should be expended, and if the prognostications of Mr. Ferranti continue to be as successful as those have been which can now be tested, the return for the capital ought to satisfy the most exacting shareholder. Whatever may be said to the contrary, and whatever may be the future of transmission of power, the prominence given to high pressure is due to the belief of Mr. Ferranti. Quite recently Mr. Kapp has given information about transmission under 25,000 volts pressure, and we have no doubt in a short time the wonder will be that high pressure of this character was ever thought dangerous or difficult. It must be remembered, however, that Mr. Ferranti has not only been the apostle of high pressure, but he has also devised mains to carry current under that pressure.

BOARD OF TRADE.

The memorandum of correspondence between the Board of Trade and various other parties will be read with interest. The upshot of this correspondence may be given in a very few words. The Board of Trade, unimpressed with the arguments made, and solicitous for the welfare of the public, refuses to alter its regulations, but "will be prepared to consider carefully any application for a modification of regulation 12 that may be made to them under" certain conditions—namely, when the application "is supported by the local authority of the district." In our view, the matter as it now stands is in a worse position than with the original clause standing unchanged. Now every attempt will be made to get the support of local authorities to the modification required. The members of these authorities, as a rule, are not experts, and information or experiments that would convince an expert will not convince the authority, though, on the other hand, a plausible tongue may gain the support of the authority upon grounds that an expert would reject. It is well known that the existing regulations hit hardest when the expenditure upon the installation does not warrant excessive cost, and in many cases makes the, say, per lamp expenditure upon a small station far and away greater in proportion than with a large station. As the memorialists put it, the rules do not press heavily for conductors of a large sectional area, but for conductors of relatively small sectional area they are practically prohibitive.

SKILLED AND UNSKILLED LABOUR.

"That is not the kind of man I want. It is easy to get young men by the score who, if asked to lift a pickaxe, will first put on a pair of kid gloves, and before going to dinner find it necessary to go to the boot-black. I had a man who was told he would probably be required to work all night, and he came provided with a black bag. 'What have you there?' says I. 'A pair of slippers, a bit of carpet, and a tooth-brush,' says the man. Such are the men who come to me by the score, but they are not the type I want."

The above is almost a verbatim report of a portion of a conversation between an employer (an electrical contractor) and other gentlemen to whom he was complaining about the dearth of the better class of labour—men who could be trusted to act as foremen. Mr. Forbes in his speech refers to the same difficulty—the having to educate labour in order to adequately perform the work in connection with electric lighting. While there is a large number of young men preparing for the higher positions in the electrical engineering market, overstocking that market, there is an absolute dearth of skilled labour, such as is required to make good foremen. The sphere of labour in connection with the laying of mains is rapidly increasing, and at the present time the most competent men to superintend this class of work are imported from the gas companies. These men, however, should supplement the experience they have gained by some knowledge of testing and jointing. The capacity to take charge of a "gang," to make rough tests and to see that the jointing is properly done, and the mains properly laid, is valuable, and will fetch its price in the labour market.

REVIEWERS AND REVIEWING.

The reviewer of the *Electrical Review* has replied to my criticism of his review. He deals first with foot-pounds, which, for lack of space, I leave for the present. Then he returns to first principles—concluding with reprinting several pages of my book *re* the use of + and –, agrees with what I then say, and says everybody else is agreed. His remarks on a most important first principle are given below, as is my reply. The experiments upon which I rely to prove my contention are being repeated, and will be given in due course. It will be clearly seen that, whatever interpretation may be given to certain experiments, my critic makes statements that are not in my book, and which are totally opposed to what I really do say. This is not criticism. The following, then, are the remarks of the *Electrical Review* upon which I comment:

"I again assert that the author is wrong in a most important first principle in regard to dynamos. He has got so inextricably mixed up with his 'loops,' 'looping,' and looped lines, that he inverts a well-known experimental fact, and hangs himself thereby. To state the matter concisely in simple words, Mr. Biggs asserts that when the conducting wires of a closed armature coil are *moving* through or *cutting* a uniform magnetic field *at right angles* there is *no* E.M.F. or electrical pressure generated in them; but that when they are moving parallel to the magnetic field (*i.e.*, cutting no lines), then the *maximum* E.M.F. is generated in them. This is a sample of the bosh in the book! At page 80 he gives a figure (68) in support of his arguments about looped lines, and near the foot of page 79 he distinctly says: 'Suppose the circuit R T B at the start horizontal'—*i.e.*, when the ideal armature wires are cutting the horizontal field *at right angles*. At the top of page 80 he says during this time the current is a *minimum*, but increases to a *maximum* when the coil is vertical—*i.e.*, when the two wires are moving *parallel* to the *horizontal* lines of the magnetic field!

"This is most certainly contrary to facts, proved over and over again by direct experiment. It is, moreover, contrary to the well-known writings of Prof. Silvanus P. Thompson, Prof. Fleming, Mr. Kapp and Mr. Esson, and other well-known authors.

"Mr. Biggs could never have tested the armature of even a simple ideal dynamo for the positions of least and greatest electrical pressure. Let him add to his stock of testing apparatus a ballistic galvanometer, an electromagnet giving a uniform field, and a search coil, and try practically to realise *facts* instead of sitting in his editorial chair and posing as a writer of heterodox electrical engineering principles. Then, but not until then, he may be in a position (aided by a better draughtsman and a competent printer's reader) to write correctly a book on 'First Principles of Electrical Engineering.'"

To the Editor of the "Electrical Review."

SIR,—Your reviewer in his original review attempted to be witty—in his reply he attempts to be wise. In both attempts he fails. I shall not travel with him in Dante's footsteps, but will confine my remarks and pin him down to his reiterated statement as regards a "most important first principle"—that being his *pièce de résistance*—his own chosen ground. You must not be surprised if I drive home to the hilt the lack of intelligence, the lack of knowledge, and the impotence of any attempt to understand, as shown by the review and the reply. I am fond of quotations, and would humbly commend a study of these sentences: "In all our undertakings let us first examine our own strength, the enterprise next, and, thirdly, the persons with whom we have to do." One more, applying directly to legitimate criticism: "The first is concerning the true correction and edition of authors: wherein, nevertheless, rash diligence hath done great prejudice. For these critics have often presumed that that which they understand not is false set down." Whether your reviewer — supported by you editorially—has used "rash diligence" and understood not, I will now see.

Has your reviewer ever heard of the "diameter of commutation?" It may be that he has, and perhaps he may also, by attentively reading the authors he so kindly refers me to, find that the position of dynamo brushes, or brushes for coils such as I refer to in my book, are placed (when no armature reactions are considered) "so that the commutation shall take place exactly as the loop passes through the vertical position" (Prof. S. P. Thompson, third edition, p. 37). Now, why are the brushes so placed, if it is not to get the greatest difference of pressure (for shortness hereafter simply pressure), and thus the greatest current? Of course the brushes are placed at the extremities of the diameter of commutation, because we thus get the greatest pressure.

In this result, I am absolutely at one both with Prof. S. P. Thompson and every practical man who ever constructed or ran a dynamo, even though I suggest a different way of getting to that result, and it is your reviewer, not I, who gives a "sample of his bosh." He distorts my language, puts it into his own words, and conclusively shows he has obtained no glimmer of the sense of the words he has read. His mind has been so preoccupied with the idea of bringing me on my knees, that there is no room for its further activity. I say the reviewer distorts my language; he does more, he attributes language to me that I do not use, and which I repudiate. I explain pressure by the looping of lines around a conductor, not by the cutting of lines by a conductor. The former method allows me, I think, to explain more simply why brushes are put where they always are, is more consistent with what obtains elsewhere, and is capable of proof as to its correctness. I will now quote Mr. G. Kapp, who explains the obtaining of pressure by the cutting of lines of force, but see what his argument comes to, p. 56. "The maximum of the E.M.F., irrespective of sign, is evidently $E = F d \frac{n}{60} 2 \pi r$. Now, $2 r d$ is the total space swept by the wire, and $F 2 r d$ is the total number of lines passing through that space." Let us see where Mr. Kapp and myself differ. Mr. Kapp argues that the voltage is due to the number of lines cut per second. I argue that the voltage is due to the number of lines looped per second. I have not said nor indicated in any way whatsoever that the *rate* of looping lines is not greater when the coil is moving through a uniform field at right angles than when parallel to the field. Mr. Kapp, to get his total E.M.F., has to calculate the total number of lines through the area of his loop when vertical. At the end of his summation his wire is vertical, at the end of my summation my wire is vertical. Both Prof. S. P. Thompson and Mr. Kapp, as I read them, agree with me in this particular, though my reasoning to obtain this result is not the same as theirs. It is your reviewer's mental aberration that has led him into a mental quagmire, unless, indeed, you prefer the other alternative—utter ignorance not only of what I say, but of the authorities mentioned and of universal practice—a retort which, under the conditions of discussion, I am perfectly justified in making. Your reviewer is in this position: He has to show that the universal practice of placing the brushes at the extremities of the "diameter of commutation" is wrong. He has to show that the maximum pressure is not due to the summation of lines cut or looped, but to some other cause.

This is what I say, pp. 79-80: "Suppose the circuit, R T B, at the start horizontal—that is, with minimum or no loops around it—the bottom member, B, being at the right hand nearest to the pole, N, of the magnet. Directly the handle begins to move loops are formed around B; *the number of loops increase till the circuit is vertical.* During this time the current in the circuit *increases* from its minimum to its maximum." (The italics are mine.) It may be a consolation to your reviewer if I state that I can show experiments to prove this statement as I intend it to be read. At the same time I can show the experiments and get the results he has in his mind. This may be queer to him, but so it is.

There is nothing here to determine the *rate* of increase at any single portion of the movement, but your reviewer might be tempted to deny that pressure is due to number of loops. If he admits that, he might say "but increase depends also upon velocity of coil." This would be fair criticism.

I never "assert that when the conducting wires of a closed armature coil are *moving* through or *cutting* a uniform magnet field *at right angles* there is *no* E.M.F.," etc. (The italics are yours.) My reasoning is just the contrary. The coil I refer to is stationary, and neither cutting nor looping when I say there is no pressure.

I may inform your readers that the difference of electrical pressure—that is, E.M.F. at the brushes of a dynamo—is least when the brushes take off from those coils wherein the rate of addition of lines or loops is greatest, and is greatest when they take off from the coils wherein the rate of adding lines or loops is least, the total pressure being the summation of a descending series of numbers representing the lines looped, and the total current is proportional to the pressure.

To make this point still clearer, let a turn of wire be in the horizontal position, when the field magnets are not excited. Now excite the field magnets and note the current. Stop excitation, shift the coil through, say, an arc of 30deg. Excite the field magnets again, and note the current. The current will now be larger because the number of loops around the conductor is larger. Shift the coil through another 30deg., and excite the field magnets again. The current is still greater. Lastly, place the coil in the vertical position and again excite the field magnets (of course, each excitation is to be similar); the current, with coil vertical, is larger than in either of the previous cases. Your contention is only correct when discontinuous action is considered, and when the lines cut, or loops added, are cut or added in such a manner that their summation does not give the total pressure, as will be the case when exploring the field to find the point of greatest pressure, but which is not the case in a dynamo, nor in a single coil moving with sufficient velocity. Of course, you have still the loophole that you did not understand me to mean what I say I do mean. I have only to say, in reply to this, that just previously to your quotation I have referred to discontinuous looping, giving momentary currents; and just after I define a volt pressure as due to so many loops *per second.* I have taken this attack on my knowledge of "an important first principle" as a sample of your reviewer's acumen, and having shown his misconception, must, like him, leave readers to form their own conclusions, for both his review and reply are so

> "Free from dull order, decency, and rule,"

that it would take more space than you can well spare to even gently inculcate the ideas that not only with regard to the "first principle," but in other cases he "has blundered."

I contend that I have proved—(1) your reviewer to have put his own words and his own interpretation in the place of mine; (2) that in this particular case of E.M.F., where coils are moving through a uniform field at right angles, except in using the word "loops" instead of "lines," I do not differ from the authorities cited; (3) that he neither understands what I say, nor the authorities he calls to his assistance.

I must retract my promise to publish and criticise all the reviewers say about my book, for this reason: that much of what has been written bears too evident an undercurrent of personal bias, which prevents well-considered, impartial criticism. You will forgive me for saying that, while I wish every success to the *Electrical Review*, even violent attacks will not continue to draw replies, though I might be in a fighting humour, and the attacks as easily put aside as the attempt to prove me wanting in knowledge of first principles.—Yours, etc., C. H. W. BIGGS.

INSTITUTION OF ELECTRICAL ENGINEERS.

ADJOURNED DISCUSSION ON MR. SWINBURNE'S PAPER ON "TRANSFORMER DISTRIBUTION."

Authorised Abstract.

Mr. A. P. Trotter said the author had been criticised for giving figures instead of facts. This criticism he considered unfair, for it was better to give figures early enough to prevent serious mistakes being made. Had Mr. Swinburne's paper on armature reactions in direct-current dynamos appeared sooner, it would have saved others from falling into error in making large Gramme armatures for constant-current machines. On the subject of transformer tests, he said the calorimeter method, to be at all accurate, involved many troublesome corrections, and would require very large vessels. The electrostatic wattmeter methods need to be tried. Split dynamometers neglected leakage, and, as the stray fields are quite different to what one would expect, serious errors may be introduced. Dr. Fleming's experiments at the Royal Institution illustrated what peculiar effects were produced by alternating fields. In such fields copper behaved very much like iron in ordinary fields, and possibly copper filings might prove useful for exploring the waste fields of transformers. Mr. Mordey's thermometer method would, he thought, involve considerable trouble if anything like accurate results were to be obtained, for since the heat was in one case generated in the iron, and in the other in the copper, the fact that a thermometer on the iron gave the same reading did not necessarily show that the energy dissipated in the two cases were identical. To obtain reliable results the distribution of temperature should be uniform, and the isothermal surfaces parallel to a casing surrounding the transformer under test. The two latter methods, curiously enough, led to the result that the losses in hysteresis become less as the load increases. This he could not understand, for if, as is generally assumed, the induction is constant at all loads, he failed to see what goes on in the transformer which would explain the new fact. Since the last meeting two valuable contributions to our knowledge of transformers had been read before the Physical Society. On the subject of the diminished iron losses at large loads, referred to in one of these papers, he would ask whether such a result was consistent with Ewing's theory of magnetism. To him it appeared possible that the losses with rapidly alternating currents may be quite different from those existing for slow cycles. In order to illustrate the fact that physical properties of materials depend on the rapidity of the changes influencing them, he showed that a piece of pitch, which was quite soft and viscous to steady pressures, yet transmitted the rapid vibrations of a tuning fork like a rigid body.

Mr. G. C. Fricker, referring to comparisons of closed and open circuit transformers, said that in estimating the loss in a closed-circuit one as 120 watts, Mr. Swinburne was in full accord with writers and teachers who hold that the magnetisation is constant at all loads. This assumption was, however, challenged by Mr. Mordey at the last meeting, and he himself doubted its truth. Great confusion, he said, existed amongst recognised authorities in the theory of the subject Mr. Kapp, for instance, in his diagram illustrating the actions taking place in a closed-circuit transformer, builds up his component forces on a line drawn to represent the maximum value of the resulting induction, and, in the speaker's opinion, thereby begs the whole question. He also asserts that the resulting induction is in quadrature with the secondary current, because this current is in consonance with the impressed E.M.F. Mr. Blakesley, starting from a different standpoint—viz., the impressed primary force, and assuming the necessary adjustment of primary and secondary currents—arrives at the conclusion that the secondary impressed force is in quadrature with the primary current. If, therefore, both Mr. Kapp and Mr. Blakesley are right, the phase difference between the primary and secondary currents is always 90deg. He (Mr. Fricker) thought one of the statements must be wrong, and asked Mr. Swinburne to point out which was correct or to reconcile the two. In view of the contradictions between recognised authorities on the theory of transformers, he thought the experimental facts brought forward by Mr. Mordey should not be lightly set aside. So far as these results would effect the comparison of closed and open circuit transformers, Mr. Swinburne might say that the open form would be equally benefitted if the new view be correct. He, however, could not agree to this, for the Hedgehog required a very large exciting current, and hence the plant efficiency would be materially lower even during the hours of full load. It was difficult, he said, to conceive the mechanism which must exist within the transformer, if Mr. Mordey's and Prof. Ayrton's figures be true, but, nevertheless, their confirmation would be one of the most interesting developments of electrical science. Speaking of calculations based on the sine law, he remarked that several months ago he arrived at conclusions similar to those proved analytically by Prof. Ayrton—viz., that harmonic variations were not essential to the accuracy of the resulting formulæ, and would give the considerations which led him to the conclusions in the *Journal*.

Dr. Fleming said Mr. Swinburne had ventilated his opinions against the orthodox views of parallel working, but, so far as he (Dr. Fleming) could see, he merely put forward old views under a new name. Armature reactions really meant mutual induction between armature and magnets, and as such their existence had always been recognised. Considerable attention, he thought, should be paid to the state of a system at a given instant, and a distinction drawn between the instantaneous inductance and the mean inductance of a circuit. Referring to Prof. Ryan's indicator diagrams for transformers, where the E.M.F. and current curves are plotted in correct relative positions, he showed how the inductance at any instant could be obtained, and expressed it by the formula $I = \frac{e - ri}{\frac{di}{dt}}$, e being the E.M.F., i the current, and $\frac{di}{dt}$ the slope of the current curve at the point corresponding to the instant considered. Inductances as found were, he said, periodic functions of time. On the subject of parallel working, he thought little or no advance had been made since Mr. Mordey's paper was read. Parallel working was then shown to be quite practicable, and is now largely employed on the Continent. At Leghorn several 150-h.p. alternators work perfectly in parallel. These machines have high resistance, small time constant, and stiff field, the conditions which, according to orthodox views, are desirable. He could not agree with Mr. Swinburne that 1,000-volts station pressure was preferable to 2,000, for the cost of the mains in the latter case was only about half that in the former. The employment of 2,000 volts did not seem to be any more dangerous, for Messrs. Ganz and Co. and the Thomson-Houston Company had many stations working at this pressure, and, so far as he had observed, the 2,000-volt alternators required no more care in working than their low-pressure exciters. He doubted whether the use of low-pressure alternators and step-up transformers would be safer or more economical, for the waste in the transformers would be considerable, and their cost would probably far exceed the figure quoted by Mr. Swinburne. The chief claims made for the Hedgehog form of transformer was that it gave a more square-shouldered efficiency curve than the closed type. Whether this was so or not was, he said, not a question of calculation, but one which experiment alone could decide. Such experiments should not be made by a wattmeter where a fine coil and non-inductive resistance were employed, for considerable error may be introduced. Although Mr. Swinburne admitted that the Hedgehog transformer required a large exciting current, he seemed to underrate the effect of this when a number of small transformers were connected up, for it would entail a great waste of coal and lower the plant efficiency. As regards sub-centres and low-pressure distribution, he said nothing could be more charming when writing a paper, but when one came to devise a practical system to work under present conditions, great difficulties presented themselves. Care should, however, be taken to run the feeders for supplying high-pressure distributors so that they terminate at points where sub-stations may subsequently be conveniently placed.

Mr. Kapp thought the efficiency of the Hedgehog transformer would be increased by closing its magnetic circuit, for this would reduce the exciting current, and by diminishing the magnetic resistance the loss would be increased; therefore the power would be less, and the plant efficiency greater. He could not see how it was possible for an open-circuit transformer, which required a large exciting current all the day, to be more efficient than a closed-circuit one. The matter could not be settled by argument, and experiment must be appealed to. Speaking of sub-stations, he said he was disappointed with Dr. Fleming's view, for the system had taken great hold upon engineers. At present, however, it would be futile to build large sub-stations. Eventually a leaf might be taken out of the book of direct current engineers, and stations to supply limited districts established. But instead of carrying coal to these stations, they would convey electric energy. Distribution could then be effected much more economically, for large or small transformers could be put in or out according to the demand. He called attention to a drawing of an automatic apparatus for performing these operations which he had designed, and said a copy would appear in the *Journal*.

Mr. F. King agreed with Mr. Swinburne about the defects of the house transformer system, but thought his estimate that the average consumption amounted to half load for four hours per day was rather too high; three hours half load would be nearer the truth, and making this correction, the all-day efficiency becomes considerably less than the least figure given in the paper. Referring to the advantages of storage, he said secondary batteries were now satisfactory things, and believed that when transformer systems could use storage, then alternate current engineers would appreciate its importance in reducing working expenses.

Mr. S. Joyce, Jun., asked whether the iron losses in transformers obtained from Mr. Mordey's and Prof. Ayrton's experiments continued to decrease with increase of load, and if they ever became zero or negative?

Major Cardew said people's opinions differed considerably as to what was meant by sub-stations. Mr. Kapp's system was expensive, but he saw no reason why transformers should not be placed in small lean-to buildings, and used to supply several houses in the neighbourhood.

Prof. S. P. Thompson hailed with satisfaction Mr. Swinburne's opinion about 1,000 volts being generally preferable to 2,000. Dr. Fleming had said that the cost of the mains varied inversely as the volts. As far as copper was concerned this might be correct, but it was not so for insulation. This, he thought, varied as the square of the volts, whilst compensations, etc., might be as the fifth or sixth power.

Mr. Mordey, replying to **Mr. Joyce**, said the efficiency curve rises and then falls again, whereas the iron losses fall to a minimum, and then rise with further increase of load. Many tests show the same result. On the subject of armature reactions, he had experimented by isolating one coil of a 50-h.p. armature from the rest, and connecting it with a voltmeter. On varying the load from 0 to 20 amperes this voltmeter remained quite stationary, whilst the pressure of the active coils fell 6 or 7 per cent. Referring to Mr. Trotter's objections to his thermometer method of testing transformers, he said magnetic leakage could not affect the result at all, and with care there was no difficulty in obtaining correct results.

Prof. Ayrton did not agree with the author's remarks on slip 4 about the words "self-induction" being meaningless when applied to an armature, and pointed out that the self-induction of a coil was not affected merely by its being interlinked with lines due to other magnetising forces. The self-induction of a coil meant the change of lines threading the coil due to unit current in that coil, and although its value would be affected by the presence of iron, yet under given conditions its meaning was quite definite. The transformer tests made by Mr. Taylor and himself had, he said, been attacked, both because they gave a point of maximum efficiency and because they showed the loss in iron to be small at full load. No doubt Prof. Ewing and Dr. Hopkinson had shown what the losses were when iron was subjected to slow changes of magnetism, but, so far as he knew, there was no proof that the same losses occur with rapid reversals. In a number of *La Lumière Electrique* for March, 1890, Prof. Roiti had given results of transformer tests made by different methods to those employed by Mr. Mordey and himself, and had been led to the same conclusion—viz., that at moderate loads the iron losses in transformers were negligible. Three independent observers, using different methods, had thus been led to the same conclusion Speaking of measuring power, he said Dr. Sumpner and himself had communicated to the Royal Society a new and simple method, quite independent of any assumptions as to harmonic variations or leakage, and at an early date he proposed making tests on both closed and open circuit transformers by this method.

Mr. Swinburne, in replying to Mr. Esson, said Dr. Hopkinson had worked out the last conditions for parallel working by getting the greatest control for a small change in the lead or lag angle, on the assumption that two equal machines were in parallel; this he pointed out was not the condition which holds in practice. To Mr. Evershed he pointed out that there was no difficulty in redressing the main current for series excitation of an alternator, for this was done daily both by Thomson-Houston and Ganz. He then observed that, though it was said that his representative closed-circuit transformer was not good enough, he had repeatedly asked for particulars of a better one, but they had not been produced. Though he had done so in his British Association paper, he was not now called upon to design closed-circuit transformers for his opponents, and in his present paper he had taken a commercial "Hedgehog" and had compared it with a commercial closed-circuit transformer. His "freezing-mixture" statement, he said, was not based on Ewing's curves, for he found that according to Ferrari's tests the loss in the whole transformer was less than the loss by resistance, and so the iron must have actually supplied power to the circuit. The readings were taken by the "split" dynamometer method, and proved its worthlessness. Mr. Mordey's figures were, he said, shown to be inaccurate by their agreement with those of Prof. Ayrton and Mr. Taylor, which were taken by the split dynamometer method, and thus gave too high efficiency, especially at full load. Whether the iron losses become small or not at full load was, he said, of little importance to his contention, for if it be admitted that they are large at no load, his point as to the superiority of the open-circuit type was proved. Any wattmeter would not give accurate results in transformer measurements, and before one is used it should be carefully checked, both with direct and alternating currents, on resistances and choking coils. As it was very important that people should have confidence in transformer tests, his firm would provide all apparatus for different tests to be carried out on the same transformers by all the well-known methods, and he hoped a good closed-circuit transformer would be forthcoming to undergo the same tests. He would be glad if Profs. Fleming or Thompson would make the tests, everything being provided for them. Mr. Kapp's and Mr. Esson's argument that a "Hedgehog" would be improved by closing the iron circuit was, he said, bad, for that would double the iron loss. The large exciting current was not a serious matter, for, although speakers had overlooked the fact, this could be supplied by condensers or by a dynamo running loose. On the subject of sub-stations, he pointed out that there was no need for buildings, for transformers might be sunk in the roadway where needed. Neither was there any necessity for automatic switches to cut transformers in and out, for if properly designed they could always be left on without appreciable waste.

UNDERGROUND CABLES.*

BY STUART A. RUSSELL.

(*Continued from page 262.*)

The tubes are now ready for laying, the jointing being completed during the process by fitting the projecting tapered end of one tube into the recessed tapered end of another, and drawing them up tight by hydraulic pressure, whilst the joint is slightly warmed to make the tapered surfaces of the paper adhere to one another. The copper sleeve already fixed to one length is now fixed to the other by corrugating it in a similar manner, and a short length of steel tube, containing a sleeve of prepared paper which had been slipped over the end before the two lengths were jointed, is drawn over the joint. This short steel tube is reduced in diameter at each end so as to nearly fit the steel tubes which form the outer protection of the concentric main, and after hot wax has been forced in to fill up the space not already occupied by the paper sleeve, these reduced ends are fixed to the protecting tubes by corrugating them.

There is yet another class of insulated conductor in use—viz., that where a bare copper conductor is supported at intervals on glass or porcelain insulators and elsewhere it is surrounded only by air; but as it is difficult to describe the insulated conductor apart from the culvert in which it is laid, I propose passing on at once to the consideration of methods of laying mains underground, and to describe one or two systems of bare conductors when speaking of the work actually done by the supply companies in London.

There are two distinct systems on which underground mains can be laid—viz., the drawing-in-and-out system and the built-in system—the essential difference between the two being, that in the drawing-in system the pipes or conduits are so arranged that the mains can be drawn in or out at any time without disturbing the surface of the road, whilst in the built-in system, access to the main is only possible by opening up the road each time.

Now an important item in the cost of laying underground mains, more especially in towns, is that of opening up and making good again the roadway or pavement. This expense, of course, varies a great deal according to the kind of paving to be taken up, the most expensive being asphalte and wood paving. As an example of what may have to be done, I may mention a case, where in order to lay a 3in. pipe across one of the leading thoroughfares in London, wood paving had first to be taken up and then 18in. of concrete, after which we had to go down another 2ft. to avoid a nest of gas and water pipes. The pipe being laid we had to fill in again, and temporarily make good the road surface, and then pay vestry charges to the amount of about 12s. 6d. per yard for relaying the roadway. In this particular case we were only allowed to work between midnight and 8 a.m., and had to leave the roadway in condition for traffic at the latter hour. This is, of course, an extreme case, which does not often occur, more especially as, whenever possible, the mains are laid under the footway; but with even the most favourable conditions the expense of opening up and making good is a considerable item, and should therefore be incurred only once. Herein lies one great advantage of the drawing-in system, as the ground once opened, pipes or troughs can be laid of sufficient capacity to carry cables which will serve to supply the greatest demand likely to arise, and the cables can be drawn in afterwards as that demand occurs; whereas with the built-in system, conductors of the full capacity must either be laid at first, when, perhaps, it is not convenient to spend money on insulated copper, which may not be actually required for some time, or else the ground must be reopened whenever additional mains are required. Again, it may at times, though rarely I hope, be necessary to cut out a fault, and the localising of a fault with accuracy is a much more difficult operation on electric light circuits than on telegraph or telephone circuits, so that although one may be able to say that it is somewhere between two points, say 20 yards apart, yet one cannot say exactly where. Now with the drawing-in system the faulty cable between two surface boxes can be drawn out and replaced by a good length, whilst with the built-in system it will be necessary to dig up the cable and examine it until the fault is found, and this latter task is no easy one, since cables laid in the ground are always protected by metal sheathing of some kind which may have to be cut off before the fault becomes visible. The advantage claimed for the built-in system is that it is cheaper, as no pipe or conduit has to be laid, but, on the other hand, it must be remembered that the cable must be protected in some way against mechanical damage, generally by sheathing it with iron, and the cost of this sheathing goes to reduce the difference in price. Although, perhaps cheaper in first cost, the built-in system must, I think, cost more for maintenance and laying additional mains, and it will not, therefore, in my opinion, prove the cheaper in the long run.

There is one other point in favour of the drawing-in system, and that is that it causes less inconvenience to the users of the roads and pavements, a point which must appeal strongly to local authorities; indeed, it would not surprise me if they were to use their influence in the near future to get a drawing-in system made compulsory by the conditions of the provisional orders.

Conduits for a drawing-in system may be cement, lined brick or concrete trenches, metal or earthenware pipes or troughs, or casings such as the Callender-Webber casing. Where brick or concrete trenches are used for a number of cables, they should be divided by longitudinal partitions into distinct ways to prevent the several cables from crossing or fouling one another. Cast-iron pipes are frequently used, and make a strong and thoroughly satisfactory conduit; wrought-iron pipes are not so good as even when galvanised or served with jute soaked in bitumen; they do not last so long in the soil. Iron troughing is sometimes used where a number of cables are to be laid, and for this purpose it should be divided longitudinally like the brick trenches. Earthenware conduits, although used in various forms in America, have not found much favour in England owing to their friability. The Callender-Webber casing of bitumen concrete is being used to a fair extent in London, but it is more friable and does not afford such a good protection against the picks of workmen as metal pipes or troughing, and its susceptibility to changes of temperature makes it necessary to shift the cables periodically to prevent them from adhering to the casing.

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* Lecture delivered before the Woodhouse and Rawson employés' lass, March 6, 1891.

For durability, economy of space, and complete protection of the cable from mechanical injury, the best conduit is, in my opinion, made of cast-iron socket pipes, each line of which may carry two cables, unless the latter are very heavy, in which case it is best to place only one cable in each pipe. For feeding mains, a surface box of cast iron or brickwork, with an iron cover frame filled in to suit the surrounding paving, should be fixed at each corner where the direction of the pipes is changed, and in straight runs at about every 100 yards, or perhaps less for very heavy cables. For distributing mains, surface boxes should be placed as above, and also at any place where important branches are led away; and provision should be made for taking off service wires to houses by substituting, opposite every alternate party wall, a length of split pipe for the ordinary pipe, this split pipe being provided with sockets into which the service pipes can be screwed. This system, as described above, for feeders, has had a long and very satisfactory trial at the hands of the Post Office Telegraph Department, and of their predecessors, the private telegraph companies; the use of cast-iron socket pipe conduits with a drawing in-and-out system having steadily increased since the time, more than 40 years ago, when the Electric Telegraph Company first commenced laying underground wires in this manner. I am unable to state the exact mileage now of the Postal Telegraph Department on this system, but in 1887 there were 240 miles of pipe containing 12,000 miles of wire underground, and this has probably been increased since then.

As the pipes are laid, a wire should be threaded through them, the ends of which are made fast at the surface boxes; and care should be taken to examine each length of pipe to see that the inside is smooth and that the way is clear through it, as any obstruction left in the pipe may be the cause of much trouble when cable laying is commenced. Should any obstruction be left in the pipe, or should the wire or hauling rope break, rods preferably of cane, say 4ft. to 6ft. long, with screw ferrules at the ends are required. These rods are passed into the pipe, and jointed together as they go in, and are used either to push out the obstruction or to pull in a fresh line.

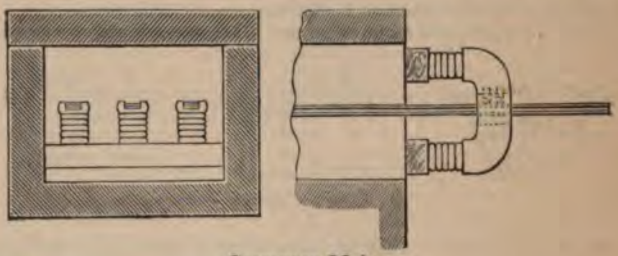
When cable is to be laid, it is brought on drums, which are fixed so that they can revolve on stands near the surface box. By means of the wire left in the pipes, a hauling rope is first pulled through, one end of which is attached by a strong but smooth fastening to the ends of the cables, and the other is pulled out above ground at a surface box further along the route. By pulling on the rope at this place it is pulled through the pipe, and it, in turn, pulls the cable after it. As the cable comes out of the surface box, it is coiled or flaked on the ground ready for passing into the next length of conduit. It is necessary to bring the cable out and coil it at each sharp bend, and in straight runs at intervals according to the weight of the cable, which determines practically the length that can be pulled at one time. The outside of the cable may be lubricated by rubbing it with soft soap, which greatly reduces the friction.

To obtain the full advantage of a drawing-in-and-out system, the mains should be divided up into sections which can easily be separated from one another, these junctions being more especially necessary where branches are taken off the main. Although this may be arranged with comparative ease in all low-pressure systems, it is not so when high pressures are used owing to the greater difficulty of preventing surface leakage of a serious amount, and we, therefore, find that in some systems it has been thought better to sacrifice some of the advantages of a complete drawing-in system so as to get the conductors covered, from start to finish, with a continuous coating of insulating material. Any continuously insulated flexible cable can be used in connection with a drawing-in system, the particular type chosen depending on the conditions under which it is to be used, and we shall see when we come to the description of bare conductor systems, that it is possible also to arrange them on a drawing-in system.

The built-in system may take several forms—viz., that of a rigid conductor in short lengths, like the Edison and Ferranti tubes, either laid direct in the ground or in a boxing filled in with cement or bitumen, or a bare conductor system, such as will be described later on; or, finally, that of a continuously-insulated cable, arranged in one of the following ways: The cable may be armoured with iron wires or tapes, and laid in the ground with a board over it to indicate its presence, a plan often followed for cheapness sake, but one that is not, in my opinion, advisable, as the mechanical protection is not sufficient; or it may be laid in a metal or wooden trough, which is afterwards filled in solid with bitumen or some such substance, a plan often followed with the idea of adding to the insulation of the cable proper by means of its surroundings.

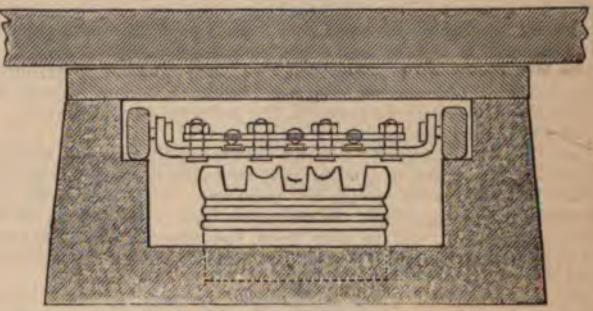
I now propose to describe briefly the systems of mains which have been laid by the supply companies in London, taking first those working on low-pressure systems.

The Kensington and Knightsbridge Company's mains consist of bare copper conductors arranged on Crompton's system, in which a cut-out of brick or concrete, 15in. to 20in. wide and about 12in. deep, inside measurement, is built under the footway. At intervals of from 10 to 20 yards, stout oak crossbars are fixed so as to leave an inch or two clear between their underside and the bottom of the culvert, and on these crossbars are arranged three or more glass insulators, corrugated on the outside of the cup to increase the length of surface, and notched at the top to make a recess for the conductor to rest in, this latter being formed of one or more strips of copper, 1in. wide by ¼in. thick. The culvert is covered by flagstones, and above them again comes the ordinary paving of the footway. At each set of insulators a manhole, with cover, is provided to give access to them. At intervals, depending on the lengths of the copper strip, straining gear is provided in the manholes, the arrangement for each conductor consisting of a gunmetal bridge, the feet of which rest against insulators fixed on crossbars. This bridge has a rectangular hole through which the conductor passes, and in which it is firmly clamped by set screws. The conductor having been put in place, one end of it is clamped in a bridge, whilst the other end, having been passed through the hole in the bridge at the further manhole, is attached to a screw-tightening gear, by means of which it is strained up tight before being clamped in the bridge. As these culverts occupy a space under the footway of two to three square feet in area, there are many places where it is impossible to find room for them, and when this is the case vulcanised rubber cables drawn into wrought-iron pipes are used. Connections are made between the cable and the bare strip by soldering a lug with a projecting tongue on to the cable, and fixing this tongue and the copper strip, both of which are tinned first, in a clamp. Joints in the copper strip are made by tinning the ends and clamping them together.

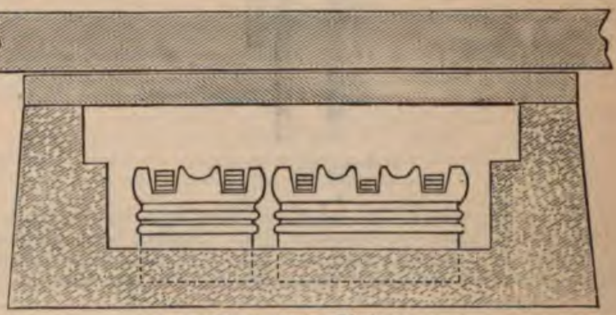


Crompton Mains.

The Westminster Company's mains, as first laid, were on Crompton's system, as just described, but the bare copper mains now being laid down by this company are being laid on a system devised by Prof. Kennedy, which has, in my opinion, considerable advantages over the earlier system, inasmuch as it has been designed as a drawing-in system, and the culvert does not occupy so much space, being of about the same width, but only 7½in. deep inside. The culvert, which is built of concrete, is wider at the top than at the bottom, a ledge being formed on each side about 4½in. up. Bedded in the concrete at intervals of 6ft. or 8ft. are stoneware insulators, notched at the top to receive the conductors, which are built up of strips 1in. by ¼in. This copper strip is straightened on the pavement by a pull from a special tool devised for this purpose, and is then drawn into the culvert, being attached to a carriage which, running on the ledge already referred to, is hauled through from the further manhole. Where there is not room for this culvert vulcanised rubber cables in iron pipes or Callender-Webber casing are used. The copper strips can be obtained in lengths of about 180ft., and joints between two lengths of strip, or between the strip and the cable, are made as already described. Service boxes are generally placed for every alternate house, and service connections are made with rubber cables in iron pipes.



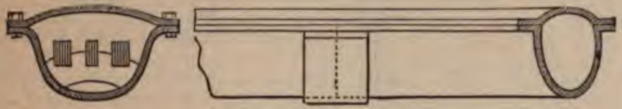
Trolley for Westminster Mains.



Westminster Mains.

In addition to the mains already described, there are some feeding mains of Siemens armoured cable, which is laid in the ground direct, merely being covered with a board, about 6in. wide, to indicate its presence. The joints in these cables are made in boxes filled with oil, as already described.

The St. James's and Pall Mall Company also use a bare conductor system, which, however, differs a good deal from those of Crompton and Kennedy. The culvert consists of a flanged cast-iron trough about 10in. wide by 6in. deep, in section like half an ellipse. These troughs are about 3ft. 6in. long, and are connected by short pieces about 5in. or 6in. long, of similar shape, which are fitted to the outsides of the troughs, and the joint run in with lead. Glazed earthenware bridges, with three notches for the conductors to rest in, are fixed in these troughs, at distances of about 9ft., and in the notches are laid copper strips, each 2in. by $\frac{1}{16}$in., placed on edge, and straightened with a mallet.



St. James's Mains.

Over the top of the conductors a second set of earthenware bridges is placed to keep them in position. A flanged and slightly arched cover is then bolted on the top, the joints between the cover and the trough, and between the lengths of cover and the butt strips which joint them, being made with red lead, and yarn brick manholes are built at about every 100ft., and are connected to the drains, and the troughs are laid with a dip towards the manholes. When connection cannot be made to the drains, arrangements are made to pump out any accumulation of water. At each manhole the conductors are connected by removable clamps. House services are made with rubber cables in wrought-iron pipes, these latter being screwed into the trough, and the cables soldered to the copper strips.

This system has the advantage that the culvert takes up much less room under the pavement than a brick or concrete culvert, but it is essentially a built-in system, and, once laid, access can be got to the conductors only by digging up the trough.

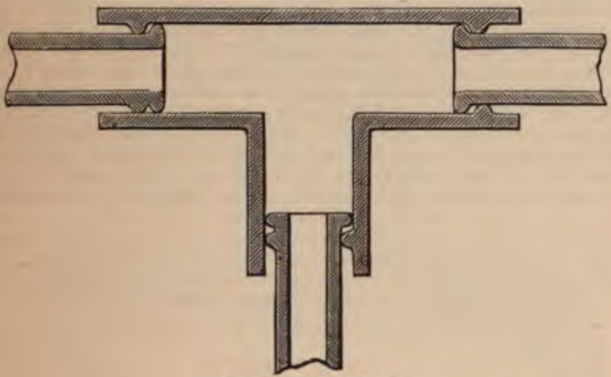
The Electricity Supply Corporation use Callender bitite cables laid in Callender-Webber casings, and in this case the precaution is taken of placing an inverted iron trough over the casing, so that it is protected at the top and sides from mechanical injury.

The Metropolitan Company, for their low-pressure distribution from the Whitehall station, also use Callender cables. These are laid in Northumberland-avenue in the subway, and elsewhere, in Callender-Webber casing.

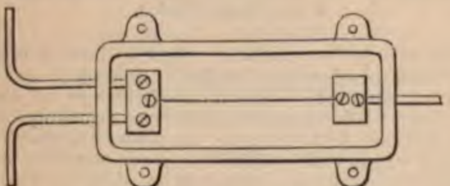
The Chelsea Electricity Supply Company, though not working an entirely low-pressure system, may be taken here, as the greater portion of their mains are for low pressure. They have, however, one charging main, which connects all their sub-stations to the generating station, and in this main the pressure is 1,500 volts. The cables used throughout are bitite cables, drawn into Callender-Webber casings.

We come now to the high-pressure systems, in all of which alternating currents are used, with transformers on the consumers' premises.

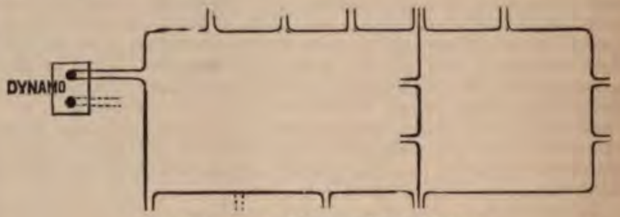
The Metropolitan Company distribute current at a pressure of 1,000 volts from their stations at Sardinia-street, Rathbone-place, and Manchester-square. The mains consist of high-class vulcanised rubber cables, drawn into cast-iron pipes. Surface boxes are provided at corners, and elsewhere as required, to facilitate the drawing in or out of the cables, and split T-pieces are inserted in place of the ordinary pipe when required for connection to consumers' premises. This system has been planned in such a manner that every consumer has a double service from the station, and so that sections of mains can be disconnected for testing, or connections made to new premises without stopping the supply to other consumers. The method by which this is effected is as follows: The current leaves the generating station by a number of mains, each of which forms a complete loop, so that, as both ends are connected to the dynamos, there are always two distinct circuits between the dynamos and any consumer. If a branch is taken off this main, it is also arranged as a loop returning to the main again. House services are not made by taking off T-branches in the usual manner, but the mains themselves are run into the house and out again, the ingoing and outgoing cable being fixed to the same block on the primary circuit cut-out. It will be seen from this that the main consists of a number of comparatively short lengths of cable, which are connected to one another at the terminals of the cut-outs, and that any one of these lengths of cable can be disconnected and removed without stopping the supply to any house. This gives great facilities for testing for a fault, and permits of a faulty length of cable being pulled out and replaced by a new length without inconvenience. It also allows a fresh connection to be made, as suppose that in any street Nos. 5 and 21 are connected up, and that No. 13 wants to be connected.



Metropolitan Mains.



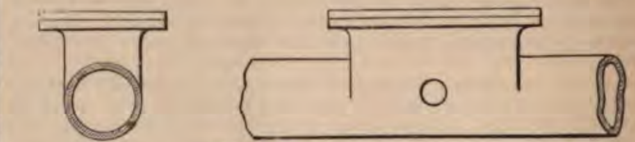
Metropolitan Primary Fuse Box.



Arrangement, Metropolitan Mains.

The cables connecting 5 and 21 are drawn out, the two houses in the meanwhile getting their supply one from each side of the loop; and a pair of cables are drawn in to connect 5 and 13, and another pair to connect 13 and 21. In addition to the distributing system from each station, the three stations are connected together by trunk mains, each consisting of four pairs of rubber cables in a cast-iron pipe, so that, if necessary, one station can help another, or all the lights on the three systems can be supplied from one station at times of minimum consumption.

The House-to-House Company at West Brompton, working with a pressure of 2,000 volts, have also adopted cast-iron socket pipes for their conduits, into which are drawn well-insulated vulcanised rubber cables. Cast-iron surface boxes are placed at all bends and places where branches are taken off, and special lengths of pipe are fixed opposite every alternate party wall. These special pipes are enlarged into boxes which are U-shaped in section and have a flat lid fixed by a clamp, and in these the house service wires are jointed to the mains. All the joints in this system are insulated with indiarubber which is vulcanised *in situ* in the manner already described.



House-to-House Mains.

(To be continued.)

CORRESPONDENCE WITH THE BOARD OF TRADE.

MEMORANDUM AND PRECIS OF CORRESPONDENCE BETWEEN THE BOARD OF TRADE, MESSRS. CROMPTON AND CO., THE BRUSH COMPANY, AND SEVERAL PRIVATE FIRMS OF CONTRACTORS; AND THE ELECTRICAL SECTION OF THE LONDON CHAMBER OF COMMERCE, ON THE SUBJECT OF THE BOARD OF TRADE RULES FOR OVERHEAD WIRES FOR ELECTRIC LIGHTING PURPOSES.

A difficulty has arisen between the Board of Trade and electric lighting contractors with reference to regulations Nos. 9 and 12 of the regulations for the protection of public safety prescribed by the Board of Trade under the provisions of the Electric Lighting Act of 1888.

Rule 9 relates to the thickness of the insulation of the wires. It states that "every high-pressure aerial conductor must be continuously insulated with a durable and efficient material to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation must not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation must be further efficiently protected on the outside against injury or removal by abrasion. If this protection be wholly or partly metallic, it must be efficiently connected to earth, so, however, as not to cause undue disturbance to other electric lines or works by electrostatic induction or otherwise."

Rule 12 states: "Every aerial high-pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires, where attached to supports, shall be in contact only with material of highly insulating quality, and shall be so attached and guarded that in case they break away it shall not be possible for them to fall away clear of the support."

The difficulty is, that although for conductors having a large sectional area—say, equal to seven No. 16 B.W.G. wires and upwards—these rules do not press heavily, for conductors having a relatively small sectional area the disproportion between the conductor and insulation is so excessive as to practically prohibit the use of such conductors, in view of their very high price and upon other grounds.

This difficulty appears never to have occurred to the committee of the Council of the Institute of Electrical Engineers, which sat for the purpose of examining and revising these rules at the request of the Board of Trade, and their prohibitory nature was only discovered in the autumn of 1889, almost simultaneously with the publication of the rules. The Brush Company, Messrs. Laing, Wharton, and Down, and Messrs. Crompton and Co. were then engaged in carrying out public lighting, and found to their astonishment that the highest possible quality of insulated conductor then made by the Silvertown Company, when the copper itself had an area not exceeding No. 13 B.W.G., although it far exceeded the requirements of the Board of Trade as regards insulation resistance, did not satisfy these conditions as regards thickness of the insulating material used.

Thinking that this was an oversight in the rules, Messrs. Crompton, in February, 1890, addressed a letter to the Board of Trade, enclosing a sample of this conductor, which was the best that could be procured, and which they proposed to use for the public lighting of Chelmsford.

The following is a *précis* of Major Cardew's reply: "He acknowledges the receipt of sample. States that it does not comply with regulations, and would be greatly astonished if the sample could be shown to have an insulation resistance of 5,000 megohms per mile after immersion in water for 12 hours with 100 volts supplied. Points out that a small wire may be quite as dangerous as a large one, and declines to accept responsibility. Suggests that it would be desirable to officially raise the question of these small overhead wires, and points out that other firms are deeply interested in the matter."

Messrs. Crompton therefore communicated with the firms named, and received a reply, addressed to Mr. Crompton in person, of which the following is a *précis*: "Acknowledges receipt of Messrs. Crompton's letter. Agrees that the thickness of insulation unnecessarily increases the cost of small overhead conductors, especially where such conductors have to be carried for miles over moorland, where such extreme precautions are totally unnecessary. Calls attention to the rule which specifies the use of bearer wires, and asks whether Mr. Crompton, who was a member of the committee of the Institute of Electrical Engineers which had the rules under consideration, could inform them whether the said committee had any idea that this rule would apply to such small conductors as seven No. 16 and seven No. 18 B.W.G. made of hard-drawn copper wire. States that in their opinion small conductors of hard-drawn copper are much safer without bearer wires as the copper is strong and practically indestructible, which cannot be affirmed of steel wires and leather hoops."

On 21st February Major Cardew wrote as follows: "Absolutely declines to pass the wire, sample of which had already been sent. Says that it might, of course, be desirable to modify these rules in the case of such small wires, but before he could agree to this he must require to see the following test performed—viz., the wire to be charged to 2,000 volts, alternating, with one pole of the dynamo connected to earth, and the experimenter to make a thoroughly good earth himself, while grasping the wire."

On February 20, Messrs. Crompton wrote, in answer to Major Cardew, as follows—viz.: "That they are prepared to submit the whole of the wire in question to test by submersing a coil in the usual manner in salt water for any reasonable period, and that the insulation resistance then taken will not be less than 5,000 megohms per mile; that the thickness of the rubber insulation on the sample was carefully prepared, and that they are informed by the manufacturers—viz., the Silvertown Company—that there is no advantage in increasing its thickness; that the extra thickness required by the regulation greatly increases the price, and gives no corresponding advantages; that the manufacturers have had a wide experience, and their opinion therefore ought to be of value; that the increased thickness would be a disadvantage since it increases the surface exposed to wind pressure. They ask whether such test would be sufficient, or whether any addition to the test suggested by Major Cardew should be applied—viz., that the alternating current of 2,000 volts should be passed through the wires, and be tested by being grasped by a living experimenter."

In reply to this letter, the Board of Trade wrote officially, stating that before modifications in the thickness of the insulation can be made tests would be necessary.

On the 22nd February the Silvertown Company wrote to Messrs. Crompton pointing out that if the best special quality indiarubber used by them were applied to their cables to the extent proposed by the Board of Trade, the insulation resistance would then be far in excess of the Board of Trade requirements.

A few days later the tests took place, and on March 1 Messrs. Crompton wrote to the Board of Trade, reporting the results as follows: "Referring to inspections made by Major Cardew of the electric lighting works at Chelmsford, we beg now to enclose a tracing of proposed alterations in the transformer casing, and request that you will be good enough to inform us whether, if these cases are used, your inspector is prepared to pass the poles carrying these transformers as strong enough for the purpose. In further reference to the same subject, we recently submitted a sample of insulated wire to your inspector, and he informs us that, under rules as they now stand, he is not able to pass that wire as suitable for the primary conductor even for street lighting purposes. We find that the requirements of your overhead rules in respect to the thickness of the insulation required for such a wire are so onerous that it practically increases the cost of the wire 200 per cent., although we are informed by those best able to judge of this subject—viz., the manufacturers of the insulated wire—that the increased thickness, which necessites this great rise in price, is not attended with any corresponding advantage in safety or security to life. We think we can prove to you without doubt that the increase in cost of conductors entailed by this rule will, in many cases, prohibit the use of electric lighting in country districts. We therefore beg that you will inform us whether there is any likelihood of this rule being modified, or, at any rate, whether we may hope for any relaxation in such special cases as at Chelmsford."

On the 17th March the Board of Trade wrote calling for tests, and enclosing the following report from Major Cardew: "As regards the question of the thickness of insulation for the overhead wires, what is asked for is a relaxation of our overhead wire regulations in one of the most important clauses, and this should certainly not be given except after most careful consideration and the clearest evidence that such relaxation is necessary to prevent undue hampering of the industry, and that no appreciable increase of risk will result to the public. I enclose the sample of wire sent to me by Messrs. Crompton and Co.

"In the first place, it will be observed that the wire itself is very thin, and it is below the minimum size which the experience of the Post Office recommends as the minimum size to be used for aerial lines.

"This, however, is not a disqualification in the present instance, as suspending wires are used; but it shows how necessary the regulation with regard to the use of suspending wires may be, and the risks to which the public might be exposed by persons inexperienced in the erection and maintenance of overhead wires.

"It is in consequence of the small size of wire that the conditions imposed by our regulations are found so onerous, and I certainly do not think that at the time that these regulations were prepared and discussed by the Council of the Electrical Engineers, the use of such small wires for electric lighting mains was contemplated.

"The thickness of insulation on the sample is, it will be noticed, far less than that specified in our regulations. In fact, it is only about one twenty-fifth inch in place of one-tenth inch. The material used is, however, of the best quality manufactured by a company of high standing and long experience.

"I have had an interview with the manager of this company in reference to this matter, and he proposes to make some lengths of special cable insulated to different thicknesses and with different qualities of material, in order that I may have the opportunity of thoroughly testing their behaviour under high alternating pressures.

"These tests are likely to give valuable information. As regards the statement that the increased thickness of insulation does not give any corresponding advantage in safety, if this merely means that after a certain thickness an increase in this dimension does not give a proportionate increase of security, I incline to the same opinion, but if it is intended to imply that a thicker insulation gives no increase of security, I distinctly differ from this opinion. The specific insulation resistance of any covering may be roughly taken to be proportional to the thickness of the coating divided by the perimeter of the outside or to the difference between the outer diameter and that of the copper divided by the outer diameter. This rule is followed by the cable manufacturers, who coat their cables of the same class to such a thickness that the outer diameter bears a constant relation to that of the copper. If $\propto$ be this constant relation, the specific insulation resistance of any class of cables will be proportional to $1-\frac{1}{\propto}$.

"If $\propto$ be as in cables of this class taken equal to 2, the insulation will be as compared with a thicker insulation where $\propto = 3$ in the proportion of half to two-thirds, a very sensible increase for the greater thickness. But in dealing with high alternating pressures, we have to consider not merely the insulation resistance of the coating as determined by tests made with a continuous low pressure, but a different kind of resistance altogether—viz., resistance to disruptive discharge either through the material and its pores, or through minute cracks in it. Now, the sparking distance in air of a pressure of 2,000 volts alternating is about one-sixteenth inch, and I certainly consider that the minimum thickness of good insulating material permissible should exceed this sparking distance. At any rate, before we could depart from this position we must have very good evidence that a disruptive discharge is not possible with the thickness and material used. And I would suggest that the attention of makers and users of cables for overhead wires should be directed towards the discovery of an insulation for this purpose, which shall be efficient and durable but less expensive than the best quality of indiarubber necessarily must be. This material need not possess a high specific resistance.

"Five megohms per mile is as good for the purpose as 5,000 provided that this resistance is uniform throughout, that the material is tough and elastic, does not crack, and is not affected by weather or temperature, or liable to rapid deterioration under the conditions to which it is subjected."

On May 1st, Messrs. Crompton wrote to Major Cardew, informing him everything would be ready for the test, and asking him to name a day for the same.

Major Cardew made an appointment to test the cables on Friday, May 9th.

The tests took place, and the following gentlemen were present at them: On behalf of the Brush Company, Mr. Sellon; the India Rubber Company, Mr. W. E. Gray; Messrs. Laing, Wharton, and Down, Mr. Wharton; Messrs. Crompton, Mr. Crompton and Mr. Pott. Three samples of cable were tested, with the result that No. 3, which was the same as the sample already submitted to the Board of Trade, and which is known as Silvertown "L" quality insulation, successfully passed all the tests, and showed itself in every respect practically equal to the other samples. The cable No. 1, which was insulated to the thickness required by the regulation, actually showed itself more liable to injury, when a kinking test was applied, than those having the thinner insulation. The cost of the samples are £28, £45, and £78 per mile respectively.

After these successful tests, it was expected that the regulation No. 9 would be modified, but on 30th of May Messrs. Crompton received the following from the Board of Trade: "With reference to your letter of the 1st March last, on the subject of the electric lighting installation of your company at Chelmsford, requesting that the Board of Trade would modify their requirements as to the thickness of insulation, I am directed by the Board of Trade to inform you, that the tests referred to in their letter of the 17th March having been made, they are not prepared to sanction any reduction of the thickness of insulation prescribed in their regulations."

After some correspondence between the gentlemen who were present at the tests, it was decided that a memorial to the Board of Trade should be drawn up and signed by those present. The matter also was mentioned at a meeting of the London Chamber of Commerce, and the following letter was addressed by the secretary of the Chamber to the Board of Trade: "I beg to inform you, that at a recent meeting of the Electrical and Allied Trades Section of this Chamber, the application by your department of articles 9 and 12 of the above rules and regulations was discussed. It was pointed out that if rule 9, which defines the thickness of the insulation of the cables, and rule 12, which orders the use of separate suspending wires, are rigorously insisted upon, it will in all cases where small conductors are used, have most disastrous effects upon trade, practically prohibiting the extension of electricity for street lighting and for transmission of power in small towns. The regulations as they stand approximately double the cost of the conductors themselves, and of the mode of suspension, without offering any greater security to the public. It appears that at the time when these rules and regulations were considered by a committee of the Institution of Electrical Engineers, no cables insulated in the manner prescribed in article 9 had then been manufactured, so that the committee had no opportunity of judging the effect of the rule. I am desired to append copy of a resolution unanimously adopted by the meeting, and it is hoped that you will give the same your careful and favourable consideration.

"*Resolution.*—'That this meeting of the Electrical Trades Section of the London Chamber of Commerce, feeling that if the Board of Trade insist upon their decision with regard to cables, as announced in their letter of the 30th May to Messrs. Crompton and Co., Limited, will be seriously detrimental to the interests of the electrical trade, while not providing additional protection to the public, earnestly solicit the Board of Trade to give their favourable re-consideration of articles 9 and 12 of the rules and regulations for overhead wires, with a view to their decision being modified.'"

On July 16 the London Chamber of Commerce received a reply as follows: "I am directed by the Board of Trade to acknowledge the receipt of your letter of the 23rd ult., enclosing a copy of a resolution passed at a recent meeting of the Electrical and Allied Trades Section of the London Chamber of Commerce, on the subject of the regulations to be issued by this department under section 4 of the above-mentioned Act with respect to overhead wires, and to state that the Board of Trade have carefully considered the resolution adopted by your Chamber, and the arguments in support of it contained in your letter. In the preparation of the regulations in question, the Board of Trade consulted the Council of the Institute of Electrical Engineers, whose members possess the highest scientific attainments, and have also large practical acquaintance with the working of electric lighting undertakings. The Council devoted a great deal of time and care to the consideration of the subject, and the regulations, as now drafted, were adopted, with some modifications not affecting the questions raised by your Chamber on their recommendation. The Board of Trade, while anxious to avoid any undue interference with trade, are compelled to have regard to the safety of the public, and they desire me to say that they regret to be unable to modify the model regulations as desired by your Chamber. I am, however, to add that they will consider carefully in the case of any particular installation on the series or other similar system, any application for a modification of regulation 12, which is supported by the local authority of the district."

On November 6 the two following memorials, signed by the Brush Company, Crompton and Co., Laing, Wharton, and Down, and the India Rubber Company, were sent to the Board of Trade:

"We, the undersigned companies, firms, and persons interested in the supply of electricity in the United Kingdom, beg respectfully to memorialise your Board with reference to regulation 9 of the regulations for the protection of the public safety, etc., prescribed by the Board of Trade under the provisions of the Electric Lighting Act of 1889.

"With reference to this regulation, the undersigned beg leave to state that it is the general experience, based upon numerous actual tests, that for pressure up to 2,000 volts, whether alternating or continuous current, a thickness of one-tenth of an inch of dielectric is unnecessary in conductors of small section.

"For conductors having a relatively large sectional area, we are satisfied with the expediency of the Board of Trade requirements, but for conductors having a relatively small sectional area, the disproportion between the conductor and the insulation is so excessive as not only to render the use of such conductors prohibitory in view of their high prices, but actually dangerous in the presence of snow and high winds on account of the very large surface presented in proportion to the total weight of the conductor and its covering.

"Four of the principal companies interested in this branch of work—viz., The Brush Electrical Engineering Company, Limited, Messrs. Crompton and Co., Limited, The India Rubber and Gutta Percha Company, Limited, and Messrs. Laing, Wharton, and Down Construction Syndicate, Limited, were represented at the experiments carried out at the works of Messrs. Crompton and Co., at Chelmsford, by your adviser, Major Cardew, and their representatives were so thorougly convinced by these experiments of the reasonable character of their request for a modification of the existing rule, that the above-mentioned companies heard of the receipt by Messrs. Crompton and Co. of the letter from the Board of Trade, dated May 30, with the greatest astonishment and regret.

"The undersigned beg leave, therefore, most respectfully to request the Board of Trade to give the decision therein communicated their favourable reconsideration, and to suggest that this rule may be modified in accordance with the following:

"'Every high-pressure aerial conductor must be continuously insulated with a durable and efficient material, to be approved of by the Board of Trade, and to a thickness of not less than one-seventh part of the actual conductor diameter, in cases where the extreme difference of potential does not exceed 2,000 volts; but for all higher voltages this thickness must be increased in direct proportion to the increase in difference of potential. In no case must the thickness of insulation be less than one-sixteenth of an inch, and the cables must have an insulation resistance of not less than one megohm per mile per volt of E.M.F. when tested in water at 60deg. F. (after immersion of at least 60 consecutive hours). This insulation must be further efficiently protected on the outside against injury or removal by abrasion. If this insulation or protection be wholly or partly metallic it must be effectively connected to earth, so, however, as not to cause undue disturbance to other electric lines or works by electrostatic induction or otherwise.'

"The undersigned are willing and anxious to conduct any additional tests which the Board of Trade may wish or suggest, in proof of the contentions herein stated.

"The undersigned make these representations while fully recognising the necessity in the interests, not only of the public, but also of the electrical industry generally, that all overhead electric lines should be carried out in the safest possible manner."

"We, the undersigned companies, firms, and persons, interested in the supply of electricity in the United Kingdom, beg respectfully to memorialise your Board with reference to regulations Nos. 2 and 12 of regulations for the protection of the public safety, etc., prescribed by the Board of Trade under the provisions of the Electric Lighting Act of 1889.

"With reference to these regulations, the undersigned beg leave to bring before the Board the fact that, in conjunction with overhead conductors having a small sectional area of copper, the use of suspending wires is not only unnecessary but exceeding dangerous to public safety, on account of the large surface presented to wind and snow and the great strain put upon the supports.

"It is admitted that this does not apply with so much force to the use of suspending wires with conductors of relatively large sectional area, but the undersigned are strongly of opinion that both in the interests of the electrical industry, and in those of public safety, it is advisable that overhead conductors up to a sectional area of hard drawn copper, equivalent to 7 No. 16, S.W.G. should be run without suspending wires.

"The undersigned beg leave, therefore, most respectfully to request the Board of Trade to give their favourable reconsideration to the foregoing regulations, and to suggest that they may be modified in accordance with the following:

"*Clause* 2.—Every aerial conductor shall be attached to supports at intervals not exceeding 200ft. where the direction of the conductor is straight, or 150ft. where this direction is curved, or where the conductor makes a horizontal angle at the point of support. If suspending wires are used, as required in clause 12, the above intervals may be increased to 250ft. and 200ft. respectively.

"*Clause* 12.—Every aerial high-pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspended wires, where attached to supports, shall be in contact only with material of highly insulating quality, and shall be so attached and guarded that in case they break away it shall not be possible for them to fall away clear of the supports. Provided that where the aerial high-pressure conductor is equal to or less than 7 No. 16 S.W.G., the suspending wires shall not be compulsory if the conductor be of hard drawn copper or other material of equal strength.

"The undersigned are willing and anxious to conduct any tests which the Board of Trade may wish for or suggest, in proof of the contentions herein stated.

"The undersigned make these representations while fully recognising the necessity in the interests, not only of the public, but also of the electrical industry generally, that all overhead electric lines should be carried out in the safest possible manner."

An answer was received from the Board of Trade, dated 13th December, as follows : "With reference to your letter of the 20th ult., addressed to the President of the Board of Trade, enclosing two memorials asking for certain alterations in the regulations for the protection of the public safety, made by this department, under the provisions of section 4 of the above-mentioned Act, I am directed by the Board of Trade to state that a request for a modification of the regulations in question was received by this department in June last from the Electrical and Allied Trades Section of the London Chamber of Commerce.

"A copy of the reply which was addressed to the Chamber after a careful consideration of the circumstances is enclosed herewith.

"The Board of Trade have given their serious consideration to the views expressed in the memorials now before them and they do not think that any fresh circumstances or arguments are adduced which would justify them in departing from the decision announced in the letter above referred to.

"As regards regulation 9, I am to point out that in the experiments at Chelmsford, to which reference is made by the memorialists, the tests were applied to perfectly new cables insulated with the best quality of indiarubber, and that although the result showed that under such circumstances the cables could be safely handled, the tests cannot be accepted as a sufficient guarantee of the safety of a similar thickness of this or other insulating materials after exposure for some years to wear and tear and atmospheric action.

"With regard to the contention of the memorialists that actual danger is caused to the public in the presence of snow or high winds by the use of conductors having a large exposed surface in proportion to their total weight, I am to point out that the requirements of regulation 3 provide an ample margin of safety against any strain to which the wires may be subjected from these causes, and that so long as those requirements are complied with the Board of Trade do not anticipate that any danger to the public will arise.

"In conclusion, I am to repeat that the Board of Trade will be prepared to consider carefully any application for a modification of regulation 12 that may be made to them under the conditions referred to in the concluding paragraph of the letter to the London Chamber of Commerce above referred to."

COMPANIES' MEETINGS.

LONDON ELECTRIC SUPPLY CORPORATION.

The fourth ordinary general meeting of this Corporation was held at the Cannon-street Hotel on Friday, the 13th inst., at 12 noon, Mr. John Staats Forbes, chairman, presiding.

The **Secretary** (Mr. C. B. Waller) having read the notice convening the meeting,

The **Chairman** said : Gentlemen, the report and accounts (*vide* our last issue) have been printed and circulated, and I presume you will take them as read, as usual. Then, if that be your wish, I should like you to follow me through the accounts in order that the figures may reveal themselves up to date. These accounts, as you know, are rendered in accordance with the form prepared by the Board of Trade. They are very comprehensive, very full, and carry forward, as they are intended to do, from year to year the state of the capital and expenditure under a great many subdivisions. I had occasion at the last meeting—I daresay much of it is forgotten—to dwell at some length upon the position of the Company at that moment. I don't intend to be at all as diffuse to-day, because I suppose the proprietors have had sufficient interest in their affairs to remember or read what took place upon that occasion ; and therefore it is rather in continuation of that text that I speak to-day. No. 1 account states the capital, and there you see that the whole of the share capital has been paid up. That is to say, the whole authorised £555,000. The preference capital last year stood at £100,000. During the year a portion of that has been paid up. You will remember that we were in some difficulty as to how to deal with the preference shareholders, because, under the arrangement of the prospectus, the calls were to be made by a particular time, and I explained at the last meeting, a year ago, that we were not in pressing need of money ; and that we thought the circumstances of the time were such as not to justify calling up the money when interest was at a very high rate, and they (the preference shareholders) would be the losers of the difference between what they would probably have to pay and what we could get for it on deposit. But, in order that there might be no ground of complaint, we offered the preference shareholders the option of paying in advance. They availed themselves of that option to the extent of £53,000, and that is the only change in No. 1 account. We have now £153,043 of that capital paid up, and £96,957 remaining in hand for obligations either incurred or coming in the future. And that is not the end of our available assets at the present moment. Of course, if that fund be exhausted, you have the 89,000 unissued shares to fall back upon. No. 2 account does not require any observations, because we have not raised any money in loans—we are all shareholders. Now you come to the expenditure. What has become of the money? And that account is very clear. At the head of column No. 1 you will find that up to the end of last year the expenditure was £504,954, and you will see by the analysis running down the two pages how that money went ; the different forms and what was expended, items No. 1 to 14. And during the year you will see that the expenditure has been very largely increased. No less than £143,501 have been spent during the year, and if you will cast your eye into the total column and look at the balance you will find it is £59,566. 19s. So that we are getting very near the end of our tether as regards capital powers. Of course you will want to know what this money has been spent upon. Look at the different headings. There they are : Buildings and general construction at Deptford, so much ; plant and machinery, so much ; mains, so much ; purchase of the business—that, of course, is the foundation of the undertaking—including some small legal expenses, stands at £250,397. Then there are other mains, transformers, meters, and so forth. And that indicates, of course, that during the year which has elapsed there must have been very considerable advance in the provision of machinery for lighting, at all events ; and that is so, as I shall be able to tell you presently. We have spent, in fact, in preparation, in progress I hope towards the completion of what may be called the first stage of our existence, £143,501 during the year. Then the revenue account is very exhaustive—on one side you have the cost, on the other side the proceeds ; and I am sorry to say that the proceeds just about balance the cost. On the first blush of it that doesn't appear a very satisfactory state of things. But the Board had prevision enough last year when we met to point out, through my mouth, that we must consider ourselves by no means out of the wood. We have, for good or evil, launched ourselves on a new path. We had no beaten way to follow. Mr. Ferranti's system, as everybody knows, is different to the accepted system under which some other companies—most other companies—are at present working, and therefore it was in the nature of an experiment—a very costly experiment if it should fail, probably a very successful one if it should succeed. And this time last year, although we were lighting up, we were not lighting up with our permanent system : we were lighting up with a temporary system which had grown from small beginnings at the Grosvenor. And we had before us the necessity of turning out from the Grosvenor and transforming all our business at the same time we were going. That is a difficulty we are labouring under to-day, and that necessity turned out to be, perhaps, somewhat in the nature of a curse, because it was owing to that state of things that that fire took place at the Grosvenor which put a sudden stop to our business. Well, I said a curse ; but, like a good many of these things, it will probably turn out to be a blessing, because although we have lost a good many customers, and although I have no doubt that during the time of that interregnum we lost a good deal of money in the nature of revenue, still it has enabled us to profit by the total cessation of business for a considerable time, to complete the thing much more rapidly than we could have done if the business had been running. Well, now, you see what these expenses are. Of course, prophesying is a dangerous game, because if it happens to turn out well—well, then it is well. But if it should turn out ill—well, then blame is generally lavished pretty freely ; and therefore old birds, like myself, are very cautious what we prophesy. At the same time you ought to know that we consider these costs represented by this account, not to be at all normal in character. We have not up to this time had the advantages which we anticipated, which we are pretty positive we shall have when the permanent system goes by itself, that is to say, Deptford. During the greater part of the time we had the Grosvenor we had to keep up a large expenditure at Deptford, because this complicated and novel machinery has to be learnt. The fact is, all this business has to be learnt. The Dutch call an inventor an outfitter, one who finds out ; and we have had to find out as we went along, and our misfortunes have arisen from the operation of a very natural law—viz., that you can't find out everything at once. Still we have found out one or two things. The main object of these observations is to impress upon you that this large expenditure, which is about equal, as you see, to the return, is not a normal expenditure ; it is quite abnormal. During a portion of the year we transmitted a portion of the supply from Deptford to the Grosvenor. Grosvenor supplied a portion of the current, and Deptford the other. Well, that was in order to test the possibility of doing what a good many people considered could not be done. They believed that this idea of transmitting electricity over so great a distance must fail. But, then, it has not failed. We had to begin, and we found the anticipations of Mr. Ferranti were entirely confirmed by the result. Then we have had a great number of mains laid on Mr. Ferranti's principle—concentric mains. The great trunk conduits which run from Deptford to London convey current which is distributed through a minor conduit, or smaller main, to the consumer. These (the trunk mains) had to be tested, and testing them is an expensive matter. Then, again, we had to clear out of the Grosvenor ; take out the engines, dynamos, and the whole of the machinery, and remove a great deal of it to Deptford. All that caused continual expenditure of money and continual interruption of business ; and, in fact, I for one am surprised that the accounts have come out as well as they have, because, in addition to the difficulties and large expense incurred in working under the conditions of the moment, came the fire, when everything went out—as you know, the converters were all destroyed, and without a converter you can't light. Well, we improved the opportunity. We were a little staggered at the moment of the fire, but we made up our minds that now was the time to postpone over a sufficient period any attempt to light, trusting to the forbearance of our customers and to their sympathy. And I may say, in passing, that we have received it without stint, and now we have lit up. But lighting up, although on a modest scale at present, still decides one or two important things. For the last two or three weeks our lighting has been done from Deptford exclusively, because now there are no means of producing light at the Grosvenor, and I am given to understand that recently, at all events, there has been no complaint about the light. When the fire took place we were supplying probably 36,000 lights, or something of that sort. Well, now we have got back 10,000, and we shall not be wanting in customers as our capacity to increase the supply increases from day to day and from week to week. Well, now, in the face of these difficulties you will see what we have taken. We managed to get by the sale of current per meter £16,280, and by sale of current under contracts £9,700; and if you had the accounts of last year before you, you would see that the total amount is very nearly identical, but quite different in division. Last year the great bulk of lighting was done by contract, and very little of it by meter. Now much the largest part is done by meter, and much less by contract, which means that in the interval we have also found a reliable meter; and we at all events—and I suppose most of our customers—will prefer to pay according to a reliable standard rather than upon the uncertain footing of contract. I have no doubt that the contracts were very bad for us; there was no experience of this business upon which to found lighting by contract. The income has just about covered the expenditure, and I, for one, am very much surprised that that is so. The fire took place on November 15, and from that time to the end of December we had no customers, and no income, but a large expenditure. I hope with that explanation you will consider it, after all, not so bad as it might have been. The time is coming near when the capital part of the business approaches its completion. Of course you cannot initiate a business of this kind, enter upon large building operations like Deptford, and put in thousands of pounds worth of machinery, without enormous difficulty and trouble; and while that class of work is in progress, it is both usual and reasonable that the bulk of the charge should fall upon the construction. But the moment the construction is finished, then you are on the footing of an ordinary commercial undertaking—the expenditure must come upon the revenue. And what we have done this year, as we were approaching the first stage of construction, is to enhance considerably the apportionment to revenue of the general charges. That item in itself would account for about £1,500, which we have put on as compared with the preceding year. The amount carried to the management expenses in the preceding year was £2,500; this year it is in round numbers £3,900, and I suppose, when the thing runs purely and entirely as a going concern, the whole of this will go against the revenue. Then another thing we have thought it better to do is, we have made a larger reserve for bad and doubtful debts and other items. We had a good many accounts outstanding when the fire came, and people were very sore; but by explanation and persuasion, and a little pleading, they took a reasonable view, and it is gratifying to know that the great bulk of our accounts have been paid up in full. There were some cases where we found it expedient to make concessions—cases of peculiar hardship—and we thought it better, as all those are not settled, to reserve somewhat more than in the corresponding year. Then as we thought the fire was a calamity, we had better get it out of our minds by charging it to revenue. The actual loss was small, only about £1,188. But the loss by stoppage of the business was a serious affair; but, as I have said, I think it has been compensated for by the opportunities it has afforded us of proceeding with our business in a more prompt and efficient fashion than would have been possible if we had had to light and construct at the same time. We carry forward a balance of £813; and last year we carried forward a balance of £920. That is the result of all the patience, responsibility, ability, etc., of the past year. Well, if that were at all the state of things which one could expect as being that under which we have got to live, it would be sufficiently discouraging. But I don't think it is. I think there is every indication that during the present year things will assume a totally different aspect. The reserve fund account is a mere formal one, in which the item is brought down from net revenue, and then there is a balance-sheet. I don't propose to go further into these accounts, except it be in the nature of answers to questions. I observe one or two critics present, and probably they will ask some questions. Well, I will answer them to the best of my ability.

Now I am going to reverse the order of things. The Directors in this Company play a comparatively secondary *rôle*. At the present moment the important factor is the engineer, and, to use a technical phrase, we had to bring him to earth last year. We had to make him report to the shareholders. We thought he had better do so again, and we adopted his report because we believed in its general accuracy. You see what it says. I daresay every proprietor has taken the trouble to read it. It is the whole story. Perhaps I can epitomise it. It all comes to this, that during the year the large expenditure seems to have been justified by the results. These concentric mains, which were an idea a year ago, are now a fact. A good many clever people thought they would not work. They do work. A good many clever people also thought that the mains could not work without great detriment to the Postmaster-General and the telephone companies. But they do work without detriment to either; and in order that this system may be not only the most economical system when it is in full operation, but also beyond question the safest system, the Board of Trade have already consented—so far as we are concerned—to suspend one of the stringent conditions of the original order under which the different lighting companies were brought into existence. We were under no circumstances to earth the current. The theory was that if we did so the Postmaster-General, the telephone companies, and the railway companies *could not carry* on their business, and there did appear, for a time, to be some fear that that was so. However, the moment these concentric mains were made, the channel for conveying the current under the earth, that difficulty vanished. Then we thought, Earthing can be done, and, if so, it will make this the safest system—which only after a great deal of difficulty, and by bringing into the matter the greatest scientific authorities, including our own engineer, Prof. Thompson, Sir W. Thomson, and Prof. Fleming, could we persuade the Board of Trade to make this concession. Having satisfied ourselves that earthing would not interfere with the Postmaster-General and with the convenience of the Post Office, we were allowed to earth. By this means all danger of fire is removed absolutely. Of course when I say absolutely, I speak relatively, but it is almost that. At any rate, those dangers which the timid apprehended have been enormously modified, and I suppose under this system electric lighting of houses will be infinitely safer than with gas, and vastly safer than with oil or candles. Now here is another remarkable thing. This 10,000 volts which is to be the normal pressure of our permanent work—well, that you know was thought to be one of the impossibilities. There were two things about it. Some people thought it could not be done at all; and others thought it could only be done at such an enormous waste in transmission as to nullify altogether the economy in production. Now we have tested that, and that prognostication has been contradicted. The loss of current between the dynamo and the transformer at the transformer station is practically nil. In our case, as in the case of all the other companies, there is an essential quantity of current lost in getting it from the transformer to the house of the customer; but between Deptford and the transformer there is practically no loss—it is quite insignificant. Then the mention of 10,000 volts pressure made people's hair stand on end. Mr. Edison's stood on end when I told him, and he is not a man likely to be alarmed. He expressed some doubts first of all as to whether it could really be done; and, if it were done, whether the waste would not be very great. People ask, Can you teach Mr. Edison anything? Well, we have taught him that. He has taught us a great deal, so it is satisfactory to help him in return. And now he will be able to turn Niagara to account, because there they must have high tension; low tension cannot do that business. But, in order to give some idea of the capacity and efficiency of these mains, let me mention that they have really been tested up to 17,000 volts with perfect safety.

I have exhausted the first paragraph of Mr. Ferranti's report, which says in other language what I have told you. There is one little paragraph in it which is pregnant with meaning, and we all ought to study it. When there is any momentary annoyance caused by the light going out, we proceed to ejaculate about the evil deeds of this Company. But, as Mr. Ferranti says, "the work of lighting was of necessity performed by unskilled labourers, who had neither experience nor training in such work." But that is not the whole story. Not only were the labourers all unskilled—as are all of us—but there was no skilled labour for this business: we had to create it. And therefore people who will take the trouble to consider this fact for a moment, will find apologies in their minds and hearts for those who have to do what we have had to do—to make and find everything out by stages. During the year the Grosvenor machinery has been moved to Deptford, and is the machinery by which we are now lighting up. We have dynamos and power working up to a capacity of 30,000 lights. The dynamos of greater capacity are finished, and are being adjusted. They have been worked, and when they are ready they will send up current to the extent of 60,000 lights; so that we have power, completed and paid up, to a capacity of 90,000 lights. We should not think of using it to the full capacity, because under the Board of Trade regulations—and, in fact, if the Board of Trade had not made any, we should have made them for ourselves—we should not work up to the full capacity, we should have a reserve. And that brings me to a little bit (in the report) that is underlined: "With these two large machines supplying your circuits, the first important stage of your undertaking will be completed." That is to say, that up to 90,000 lights we have practically done all the work. There are some details now to be completed. Mr. Ferranti is always finding out something. He is finding out that he can produce electricity on a great scale at Deptford with perfect ease, and transmit it to London with equal ease and with great economy. He has not found out quite enough about the little intermediate bit between the transformer station and the customer's house. He is busy upon that, and I am quite sure that the mind—and I had almost said genius—which has overcome the difficulties which he has overcome during the last two years, can overcome the lesser difficulties in that problem. Our experience of the fire gave us an opportunity of recasting our transformer, of which we availed ourselves. As you know, there have been one or two fires in London not exclusively connected with the lighting of this Company; but we are all critics of each other in a new business, and the experience of one company is very much at the service of another, and that experience has been utilised with reference to the wires and installation in the consumer's house. It may as well go forth to the world from me that the consumers themselves will be chiefly to blame if fire forms an element of serious consideration in electric lighting, because, in an installation conducted with care, and in accordance with plans which are now thoroughly well understood and adopted by the insurance companies, fire is next to an impossibility. But, of course, if that work is done in a scamping, slovenly, unscientific manner, there will be a risk. One hears of gas put up perhaps in a not altogether workmanlike manner, and the result is you have a blow up. Water-pipes are not always trustworthy, so that every installer should take care that his work is put into proper hands. This, however, is his affair not ours.

Now we come to the second stage. You see our money is running short, and it is with companies just as it is with men. If you start young with a full purse, you are never easy till you get to the bottom of it. You only begin to be prudent as the last gold pieces come out. That is our condition. We are now going to be mighty prudent; that is to say, before entering upon the next stage of our operations—the stage which will develop 200,000 more lights. We shall want some more money. Well, I don't think we shall get it. I don't think I shall have any hand in trying to get it until we have established the first stage as a profitable commercial undertaking, because, if you were to attempt to raise money until that is completed, you could only raise it upon disastrous terms. I think when we have got 60,000 lights—which will mean, perhaps, more than £60,000 in income—we shall have no difficulty in going into the more heroic thing. I hope that won't be long. I am too old to be caught prophesying, but perhaps some sanguine man—here is the Secretary, for instance, who is very sanguine—would say no doubt we shall have 60,000 by this time next year. Well, it may be. If it be so, we may anticipate, from what we know, that our position will be so enhanced that there will be no difficulty about money for further progress. I want the shareholders to be good enough to take this on the strength of Mr. Ferranti. Let me introduce you to him. (Mr. Ferranti rose and acknowledged the hearty applause which greeted his name.) I don't know any man who during the past year has had a more terrible responsibility upon him than Mr. Ferranti. He pledged his reputation, his fortune, and his labour day and night to achieve the result he had promised the Directors. He has achieved it—greatly. And he has done so much in redeeming what a year ago seemed a most difficult and most uncertain position, as I think entirely to justify his present opinion which is expressed in this paragraph: "I desire to call attention to the fact that from the commencement of your operations to the present time no engineering or electrical difficulties whatever have arisen which I have not been able to overcome, and at the present time I know of no weak point in your system, and consider success to be now assured." That is his frank opinion. He is a man with convictions of his own, very strong willed (I have a good deal of trouble with him sometimes); but he would not say this if he was not absolutely convinced of its truth; nor would the Directors have allowed it to appear in the report, unless they had felt quite sure that they could believe it themselves. The next paragraph deals with the fire, and he (Mr. Ferranti) says, as I say, that although it came in the nature of a curse, it has turned out to be a blessing, and has enabled us to proceed much more rapidly than we should otherwise have done. Here is another of our difficulties. You know the bogey of overhead wires. Oh! by the bye, Parliament is sitting upon them at this minute. Well, there is nothing in it. Still, everyone thinks he is going to be killed by overhead wires; and, therefore, when the companies in London got their concessions or orders, they were put under the obligation of removing these wires in two years. Our time is up in August, and the whole of our current was conducted from the Grosvenor until very recently by overhead wires. Then we cut off the connection between these wires and the Grosvenor, and as we had to get out by August, we availed ourselves of the interregnum to put in underground mains for our customers, and this has been going on from day to day. This means removing the transformers from the top to the bottom of the houses; but no doubt that would be done by August. Our switching gear was another difficulty, but this has been greatly modified and improved by Mr. Ferranti. We have secured sites for three additional distributing stations. I daresay anybody who lives in the neighbourhood of a steam engine will know the difference between a generating station and a distributing station. I have been in the neighbourhood of some London generating stations at night which have not been altogether silent There are other evils attending these buildings in the centres of population. The vibration is a terrible implement in the hands of the speculative lawyer. I was connected with a company before you were in existence—we have now descended to the modest business of lampmaking, and no longer instal. But, at the time I am speaking of, we were a supply company, and had several installations about London. We got out of them as rapidly as we could at a loss, because the speculative lawyer got up damages for vibration, and we had to compound and get out. Well, I hope our rivals—no, not rivals, there is no room for rivals—those who are working with us—will not find these disadvantages. We found them out at the Grosvenor, because we were put under injunction from the Court. Our present method is very silent and quiet.

In the last paragraph of his report Mr. Ferranti says: "The great advantage of the high-pressure system is apparent in that the loss involved in transmission of current from Deptford to the distributing stations is inappreciable, while the facilities for procuring coal and water there, sufficiency of room for machinery and appliances, and freedom from the legal and financial consequences attending the erection of generating stations in crowded neighbourhoods, cannot fail to tell their own tale in the working expenses of the current year." Now, that just shows what a young man he must be, because you see he has said there something very encouraging to you; but he has put himself under a serious obligation, which is to cut down the current expenses of the year. I should not have done it, but now he has done so he is bound by it. I have nothing more to say, because the peculiarity of our two last reports is that they have been mere echoes of Ferranti; and having had him at first hand you will probably not care to have his report diluted by anything we can say. We have trimmed it up in a little different language, but it really means all that I have told you. We have weathered the storm, overcome great difficulties, see daylight—that, I think, is the opinion of my colleagues and our engineers, because we have not only Mr. Ferranti, but Dr. Fleming, who is good enough to advise us, and is an electrician of the greatest eminence. He is quite at one as to this, and has watched the system very narrowly. We believe now we have really entered upon a stage which will lead to prosperity; at all events we hope so. I will take this opportunity of expressing to our customers the deep thanks of the Board for the enormous amount of forbearance and consideration which they have shown us under circumstances which entailed considerable annoyance and probably loss. They have almost unanimously met us by the greatest consideration and —have paid the bill. As to the Board of Trade—well, a more efficient, honourable, disinterested, and courteous body of officials do not exist in any country. They have also shown great consideration and forbearance for us, and have assisted us to overcome our difficulties. The Directors feel deeply indebted to Major Cardew for the almost brotherly interest he has taken in Mr. Ferranti and his doings. The Board of Trade have done everything they could to afford this Company a chance of establishing its system, and I feel—and I am sure the shareholders will feel—that they deserve our best thanks on that account. I will move that the report and accounts be adopted.

Lord Wantage seconded the motion, which was carried unanimously; as also were resolutions re-electing the retiring directors, Messrs. Francis Ince, Joseph Pyke, and Arthur F. Wade; and the auditors, Messrs. Kemp, Ford, and Co.

A vote of thanks to the Chairman and the Board concluded the meeting.

SOUTH OF ENGLAND TELEPHONE COMPANY.

An extraordinary general meeting of this Company was held on Monday last at Winchester House, for the purpose of considering a proposal for the sale of the Company's property to the National Telephone Company.

Mr. Bateson, chairman of the Company, presided.

The **Secretary** (Mr. F. L. Robinson) having read the notice convening the meeting,

The **Chairman** said the shareholders had been informed by circular that the Directors proposed to sell the Company and its assets to the National Company. Personally, he had had little to do with this matter. When the National approached the South of England Company with reference to its business, it was decided to appoint a sub-committee, in whose hands the negotiations were placed, and, after numerous conferences, they resolved to recommend the terms embodied in the circular. They were asked to assent to this sale. He would call upon Mr. Eillett, his co-director, who would doubtless satisfy them that the proposal was a fair one, and should be accepted.

The terms of the proposed sale, as set forth in the circular mentioned by the Chairman, were: "The National Telephone Company to take over the business of this Company as from November 1st, 1890, together with all assets and liabilities. The profits of the business for the six months prior to the above date to be at the disposal of the shareholders of this Company. The purchase consideration payable by the National Company consists of: 1. 12,000 fully paid ordinary shares of the National Company, carrying the dividend accruing on 30th April next. 2. 4½ per cent. debenture stock of the National Company for £70,000. 3. Interest at 6 per cent. per annum on the paid-up amount of the preference shares from 1st November, 1890, until such date as the debenture stock is issued. 4. The amounts paid in advance of calls on the preference shares, with interest, from 1st November last, at 5 per cent. per annum, until date of repayment. The debenture stock is equal to the amount called up (£3. 10s.) on the 20,000 preference shares, while the 12,000 ordinary shares of the National Company would on a *pro rata* distribution give one share of £5 for 25 ordinary shares of this Company of £1 each. The immediate advantage of this arrangement is obvious. The dividend on one £5 ordinary share in the National Telephone Company last year was 6s., as against 2s. 6d. on 25 £1 shares in this Company."

Mr. Billett then addressed the shareholders in favour of the proposed sale, and moved the first resolution as follows:

"That the agreement submitted to this meeting, and expressed to be made between this Company and the National Telephone Company, Limited, for the amalgamation of the two companies, by a transfer of the business and property of this Company (with certain exceptions) to the National Telephone Company, Limited, be, and the same is hereby, approved."

Mr. M'Gregor, another director, seconded the motion.

Some discussion then ensued, several shareholders protesting vigorously against the sale, while others supported it. However, on the **Chairman** putting the resolution, it was carried by 25 to 14.

Mr. Billett then moved, and **Mr. M'Gregor** seconded, the two following resolutions, both of which were carried without opposition:

"That with the view of giving effect to the above-mentioned agreement, and in order to enable the debenture stock and shares to be allotted thereunder, as part of the purchase consideration, to be distributed among the members of this Company, this Company be wound up voluntarily under the Companies Acts, and that Mr. Thomas Abercrombie Welton be, and he is hereby, appointed liquidator for the purpose of winding up its affairs and distributing its property."

"That pursuant to the 161st section of the Companies Act, 1862, the liquidator be, and he is hereby, authorised to carry the said agreement into effect, and to receive the debenture stock and shares agreed to be allotted, and the cash payable thereunder, and to distribute the same among the members of this Company."

A vote of thanks to the Chairman concluded the proceedings.

NEW COMPANIES REGISTERED.

Liverpool and District Pulsion Telephone Company, Limited. Registered by Thomas T. Hull, 22, Chancery-lane, with a capital of £6,100 in £1 shares. Object: to adopt an agreement made February 20 between the Primary Syndicate, Limited, of the one part and Alfred Howard Cowie of the other part, and to carry on generally the business of a telephone, telegraph, and electric light, etc., company. There shall not be less than three nor more than five Directors. The first are to be appointed by the subscribers to the memorandum of association. Qualification, 100 shares. Remuneration to be determined in general meeting.

CITY NOTES.

West Coast of America Telegraph Company.—The receipts for February were £4,600.

Western and Brazilian Telegraph Company.—The receipts for the past week were £4,063.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £5,066.

City and South London Railway.—The receipts for the week ending March 14 were £749, against £731 for the week ending March 7.

West India and Panama Telegraph Company.—The estimated traffic receipts for the half-month ended March 15 were £3,093, as compared with £3,461 in the corresponding period of 1890. The November receipts, estimated at £5,378, realised £5,467.

United Asbestos Company.—At the annual meeting of this Company a dividend of 10 per cent. was declared and paid upon the preference shares, and the balance of profit for the year, equal to a little over 5 per cent. on the ordinary shares, was carried forward.

The Eastern Telegraph Company announce the payment on April 14 next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum, on the Company's preference shares, for the quarter ending March 31, and the usual interim dividend of 2s. 6d. per share on the ordinary, free of income tax, in respect of profits for the quarter ended December 31 last. The register of transfers will be closed from April 7 to 14, both days inclusive.

PROVISIONAL PATENTS, 1891.

MARCH 9.

4170. **An improved method for the distribution of electricity.** William Henry Willatt, 28, Witham, Hull.

4188. **Improvements in electrolysis.** Jonathan Aldous Mays, 20, Daleham-gardens, London.

MARCH 10.

4214. **Improvements in telephones.** James Frederick Bennett and Ernest Parker Hides, 30, Violet Bank-road, Nether Edge, Sheffield.

4215. **Automatic electric block-signalling on railways, with mechanical arrangement for testing the same.** Archibald Drummond Macdonald and James Dodd, 23, Spellow-lane, Liverpool.

4235. **Improvements in transmitter for electric step-by-step telegraphs.** George Edwin Fletcher, 4, Clayton-square, Liverpool.

4256. **Improvements in insulation of electric conductors.** Frederick James Nash, 55, Chancery-lane, London.

4259. **Improvements in electric motors.** Henry Harris Lake, 45, Southampton-buildings, London. (The Giant Electric Motor Company, United States.) (Complete specification.)

4263. **Improvements in means for preventing induction in telephones.** Thomas F. Wright and Ed. G. Wilson, 45, Southampton-buildings, London. (Complete specification.)

4269. **Improvements in insulated electric wires.** Frederick James Nash, 55, Chancery-lane, London.

4271. **Improvements in electrical railway signalling.** Philip Arthur Newton, 6, Bream's-buildings, London. (The American Electric Railway Signal Company, United States.) (Complete specification.)

4306. **Improved methods of and apparatus for obtaining electricity and in connection therewith.** William Boggett, 34, Southampton-buildings, London.

MARCH 11.

4367. **An improved electric signal and search-light lantern.** William Henry Munns, 55, Chancery-lane, London. (George Washington Martin and Josiah Knight, United States.)

4374. **An electrical singeing apparatus for textile fabrics.** Ludwig Lettré, Barmen, Germany. (Complete specification.)

4392. **Improvements in electrical bell and electrical alarm clock apparatus applicable for use either in combination or separately.** William Entwistle, 46, Lincoln's-inn-fields, London.

4407. **Improvements in the electric connection of lightships with the mainland.** Ferdinand Linke, 53, Chancery-lane, London.

4410. **An improved telephone enunciator or indicator.** William Wilson Horn, 151, Strand, London. (George R. Lawrence and Charles H. Oakwood, United States.)

MARCH 12.

1051A. **Improvements in testing electrical transformers and dynamos during the manufacture of the same.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London. This application having been originally included in No. 1051, dated 20th January, 1891, takes, under Patents Rule 23, that date.

4468. **An improvement in cases for electrical switches, safety fuses, ceiling roses, and similar fittings.** Charles Denton Abel, 28, Southampton-buildings, London. (Heinrich Messing, Germany.)

4469. **An improvement in resistances employed for electrical measurements.** James Clegg, 28, Southampton-buildings, London.

4471. **Improvements in electrical switchboards and fuseboards.** William White, 28, Southampton-buildings, London.

4479. **Improved means for insulating underground electrical conductors.** Luis Ferdinand Harry Courthope Morgan-Grenville, 191, Fleet-street, London.

4482. **Improvements in and relating to telephonic switchboards.** Charles Jonathan Prickett, 20, High Holborn, London.

MARCH 13.

4499. **Improvements in microphones.** Herman Oppenheimer, 62, St. Vincent-street, Glasgow. (Actien Gesellschaft Mix and Genest, Germany.) (Complete specification.)

4551. **An improved tablet or pad for use in connection with telephones.** Henry King, 60, Chancery-lane, London.

4554. **Improvements in armatures for electrical machinery.** George Frederick Redfern, 4, South-street, Finsbury, London. (Wirth and Co., agents for W. Lahmeyer and Co., Germany.)

MARCH 14.

4579. **Improvements in switches for electric cigar lighters and like purposes.** Gustav Binswanger and Charles Henry Smeeton, 71, Queen Victoria-street, London.

4583. **Improvements in electric supply meters.** John Perry, 31, Brunswick-square, London.

4588. **An improved counter-weight arrangement for electric lamps.** John Makintosh Mackay Munro, 154, St. Vincent-street, Glasgow.

4605. **Improvements in electric lighting and for other like purposes.** Robert James Rae, 85, Gracechurch-street, London.

SPECIFICATIONS PUBLISHED.

1890.

3096. **Electric meters.** De Ferranti. 11d.

4086. **Dynamo machines.** Barley and Stevenson. 6d.

4235. **Filaments for electric lamps.** Rees. 6d.

4260. **Electric distribution.** Thompson (Young). 8d.

5678. **Electric tension regulators.** Kalb. 8d.

6005. **Electric lamp adjuster.** Sayer. 6d.

13799. **Electrical signalling.** Lake (Electric Secret Service Company). 8d.

18266. **Conduits for electric tramways.** Davies and Dutson. 6d.

20126. **Galvanic batteries.** Dutton. 8d.

20540. **Welding metals electrically.** Thompson (Coffin). 6d.

21143. **Electric batteries.** Rhodes. 6d.

1891.

536. **Dynamo-electric generators, etc.** Atkinson, C. W. and L. B. 6d.

667. **Voltaic accumulators.** Thompson (The Hess Electric Storage Battery Company). 8d.

669. **Electrical cut-outs.** Puluj. 8d.

1114. **Electric railways, etc.** Churchward (Robertson). 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2¼
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2¼
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4¾
Electric Construction	10	7¼

NOTES.

The Grand Hotel, Paris, is being thoroughly and artistically fitted throughout with electric light.

Electric Manager.—The *Times* advertises the want (by R. I., Street's, Cornhill) of a manager for a new electric light company.

Spain.—The Allgemeine Company are erecting a central station at the Aranjuez for 30 arcs and 1,200 incandescent lights, actuated by a turbine driven by a waterfall.

Palermo Exhibition.—An exhibition will be opened on the 1st November at Palermo. The Italian Chamber of Commerce at Paris will forward a programme to those interested.

Civil Engineers.—The paper before the Civil Engineers on April 7th is on "The Cost of the Generation and Distribution of Electrical Energy," by Mr. R. E. B. Crompton, member.

Berlin-Vienna Telephone.—As a pendant to the opening of telephonic communication between Paris and London, preparations are being made for creating similar facilities of intercourse between Berlin and Vienna.

Paper at Newcastle.—Before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle, on Monday, Mr. W. C. Mountain read a paper on "Electrical Engineering, with Special Reférence to Electric Lighting."

Electrical Engineer.—A good opening for a first-rate mechanical and electrical engineer, to commence at £300 a year, is presented in the needs of the Bristol Corporation for a superintending engineer at the end of June next.

Amalgamation.—We learn that the business of Mr. Napier Prentice, electrical engineer, Stowmarket, has been amalgamated with Messrs. Easton and Anderson, Limited, where enquiries for dynamos and motors are to be addressed.

Electric Power.—The. Royal Foundry of Wurtemberg, at Königsbronn, now employs electricity to run its 25 lathes, consuming 40 e.h.p. The fire which used to produce steam for driving the engine is definitely extinguished.

Sausage Making by Electricity. — One of the novelties not noticed by us in our description of the St. Pancras exhibition last week is an "Ovans" sausage-making machine, driven by one of the General Electric Traction Company's motors.

Barnet.—As will be seen elsewhere, tenders are invited by the Barnet Local Board for the supply to their district of electric light by contract on and after the 1st of September next. The particulars can be obtained on application to the clerk, Mr. H. W. Poole, Barnet.

E.M.F. of Lightning.—It has been calculated that the E.M.F. of a bolt of lightning is about 3,500,000 volts, the current about 14,000,000 amperes, and the time to be about $\frac{1}{20000}$ part of a second. In such a bolt there is an energy of 2,450,000,000 watts, or 3,284,182 h.p.

Gasmen Displaced.—In Toronto some 30 lamplighters had recently to be dismissed on account of the spread of electric light. The gas company, in order to make the position easier for the men, gave a thousand dollars to be distributed weekly until exhausted.

Brooks System.—Mr. David Brooks has offered to the city of Philadelphia the free use of his underground system of electric mains, with liquid oil insulation, with which he claims a 3in. pipe carrying 500 telegraph or telephone conductors, can be laid at the cost of £330 per mile.

Leeds.—The Parliamentary Committee of the Leeds County Council were occupied on Tuesday in discussing the respective merits of the three schemes which as many companies put forward for illuminating certain portions of the borough by electricity, but no definite course of action was resolved upon.

St. Pancras Exhibition.—The continued popularity of electricity at exhibitions is clear from the success which has attended the one now open at St. Pancras Vestry Hall. For the second time the managers announce the extension of the time for which it will remain open. It will not close before April 1st.

Hanley.—The General Purposes Committee of the Hanley Town Council reported that the provisional order enabling the Council to supply electricity within the borough, for public and private lighting, had received the assent of the Board of Trade, and now only awaited the formal confirmation of Parliament.

Accumulators in Central Stations.—A paper upon this subject by H. Muller is given, with diagrams, in *L'Electricien*, translated from the German. The author uses two batteries in combination with hand regulation. The arrangement is used for feeders on the two or three wire system of distribution.

Sheffield.—At a meeting of the Parliamentary Powers Committee of the Sheffield Corporation on Tuesday the question of electric lighting was discussed, and the committee considered a mass of information obtained by the borough surveyor from other towns. The committee came to the conclusion that nothing should be done in the matter at present.

Derby.—At a lecture on electricity given in the Mechanics' Institute, Derby, last week, it was stated by Alderman Hobson that Sir Frederick Bramwell had been to Derby, and was preparing a scheme for lighting that town by electricity. It would shortly be laid before the Town Council, and would probably be adopted for the central portion of the borough.

Royal Institution.—Prof. Silvanus P. Thompson, D.Sc., will give four lectures on "The Dynamo," before the Royal Institution, on Saturdays, April 11, 18, 25, and May 2; tickets for the course, half-a-guinea. The Friday evening meetings will be resumed on April 10, when Sir W. Thomson, Pres. R.S., will give a discourse on "Electric *v.* Magnetic Screening," at 9 p.m. Succeeding discourses will be given by Prof. A. W. Rücker, Prof. Ewing, and others.

Huddersfield.—The monthly meeting of the Huddersfield Town Council was held last week. It appeared from the minutes of the Electric Lighting Sub-Committee that tenders are being sought from the House-to-House Electrical Supply Company and the Brush Electrical Engineering Company for the supplying and fixing of dynamos capable of supplying electricity for 500 lamps of 10 c.p., and that the Council's gas manager had been asked to furnish a plan of a site for an electric lighting station.

Another Crystal Palace Exhibition.—It has been decided by the directors of the Crystal Palace Company to hold at the Palace in the autumn another great electric light exhibition. The last exhibition of the kind, in 1881-2, was deservedly popular. So much progress has been made in the last 10 years that the directors ought to be able to eclipse their former beautiful display; and we are informed that every endeavour will be made to give special distinction to the autumn exhibition.

Wiring.—The following is a list of prices quoted for wiring The Blue Posts Tavern, Old Bond-street. The estimates were all made to one specification, and were submitted to Robt. Willey, Esq., F.R.I.B.A., of 66, Ludgate-hill: Crompton and Co., £111. 14s.; Strode and Co., £99. 14s.; B. Verity and Sons, £97; Brush Electric Lighting Company, £96; Woodhouse and Rawson, £61. 3s.; Dobson and Co., £47. 10s. (accepted).

Coventry Electric Bells. — Tenders for laying electric bells between the Coventry Police-station and the residences of the members of the fire brigade had been submitted as follows to the Fire Brigade Committee: A. H. W. Radcliffe, Birmingham, £139. 14s. 3d.; Matthews, Ball, and Preston, Leicester, £80. 10s.; Blenheim and Co., Egham, £85; E. J. Gillett, Richmond, £68; and of the National Telephone Company, to fix and maintain bells at the annual cost of £20. The matter was referred to a sub-committee to consider and report.

Calcutta and Bombay Telegraph.—It was a great event in the annals of Indian telegraphy when one day last week, says the Indian *Engineer* of Feb. 28, the new copper wire just completed between Calcutta and Bombay, along the line of the Bengal-Nagpore Railway, was worked direct for the first time. Messages at once poured in as fast as the operators could receive and signal them, showing how the line is likely to be appreciated by the public. The total length of the circuit is nearly 1,300 miles, and the Indian Department can now boast that it works the longest aerial circuit in the world.

Air Ship.—An air ship, by Mr. E. J. Pennington, is on view in the Exposition building at Chicago, and daily makes its trips. It is 30ft. over all, with an oblong silk gas container filled with hydrogen. It has a propeller in front 6ft. tip to tip, for which electricity is used as a motive power. A small Edco motor, running at 700 revolutions per minute, and geared to drive the propeller at 70 revolutions. When in the air the vessel carries only the motor, the current being fed through a conducting cable leading down to six accumulators in the ground. It is said that the model has been run at 14 miles an hour in the exhibition building.

Proposed Telephone to Brussels.—It is stated that Belgium will propose to the British Government to try the experiment of telephonic communication between Brussels and London, and to lay a cable from Ostend to Dover for that purpose. Brussels and the chief industrial and commercial centres—such as Antwerp, Ghent, and Verviers—are mainly interested in the success of the project, as thereby they would be brought into closer communication with London, Manchester, Birmingham, Liverpool, and Glasgow. The telephone between London and Paris having been so successful, it is hoped that good results will also be obtained with Brussels.

Suez Canal.—Year by year the number of vessels traversing the Suez Canal by night increases. An interesting table in Consul Burrell's report on the trade of Port Said shows that 2,836 vessels last year used the electric light in the Canal—or nearly seven-eighths of the total number passing through. The time of transit was further reduced last year. In 1889 it was nearly 26 hours, last year it averaged 24 hours 6 minutes on all the vessels passing through. The average time for the vessels using the electric light and steaming at night was 22½ hours. The shortest time taken was 14 hours 15 minutes, and *this passage* of last year breaks the record.

Water Resistance.—For those who have to manipulate or experiment with large currents a liquid resistance is very useful. A new form made by MM. Lyon et Henry is simple and easily regulated. A tube, or vessel, of insulating material contains the acidulated water. At the bottom is fixed a hollow cone of metal, communicating to a terminal outside. Exactly fitting into this hollow cone is another cone which can be raised or lowered by a screw passing up through the head of the vessel. The moving of this screw raises or lowers one cone into the other, altering by slight degrees the thickness of the layer of water between the large surfaces of the two cones.

Evolving Oxygen Electrically. — M. D'Arsonval has recently described the process by which for some years he has evolved oxygen electrically for use in his laboratory. The solution employed is of caustic potash dissolved in three volumes of water. Four voltameters of sheet iron are used, about 3in. diameter by 2ft. high, enveloped in calico or *linen*, making a porous vase. This liquor is taken to avoid attacking the iron. Each voltameter receives a current of 60 amperes. There is no other expense if the current from a dynamo is obtainable in the laboratory, and this process advantageously replaces the chlorate of potash method. M. D'Arsonval collects in this way about 150 litres of oxygen a day.

Barnsley. — The usual monthly meeting of the Barnsley Town Council was held on Monday. On the minutes of the Park and Lighting Committee being read, it was stated that a letter had been received from the Board of Trade with respect to the electric light. Councillor J. H. Bailey asked if the committee had taken into consideration the desirability of asking for an extension of time. The further it was put back the better for the Corporation, for something new would doubtless turn up every week. Alderman Blackburn, chairman of the committee, urged that the questions asked would be better answered at the next meeting, when they expected specific proposals to come before them.

Station Indicator.—The directors of the City and South London Railway Company are introducing on their trains a novel system of tablets which indicate to passengers the name of the next station. Attached to the panel of the door of each carriage is a plate bearing the words, "Next station," whilst immediately below the plate is an oblong aperture through which the name of the next station is visible. Thus, on leaving the City Station, the guard turns a handle and causes the word "Borough" to appear behind the aperture, showing that the Borough is the station which is being approached. This process is repeated at each station. The system is new in England, but is well known on the Continent and in the United States.

Water Power from Turbines.—There has existed at Gresivandan, near Grenoble, in France, for the last 15 years, a water-power plant under the unusually large pressure of 500 metres head of water. The *Zeitschrift des Vereins Deutscher Ingenieure* remarks, with reference to this, that this is the highest waterfall as yet utilised for a turbine plant. The waterfall has driven a turbine of 1,500 h.p. since 1875. The real inventor of the turbine for practical purposes was Fourneyron, and the first one was worked in 1827, and he received a patent in 1832 for constructing the first turbine for water power on a large scale. Obergrath Henschel, in Cassel, designed a turbine in 1837, and carried it out in 1841 in a stone-grinding mill in Holzminden.

Rent of Electric Railways.—Among the items of electric railways which continue to spring up in all directions in America, the following may be of interest. An electric freight (or goods) and passenger railway will be built in Fall River, Mass. The proposed site is almost entirely private property, the owners of which are favourable to the scheme. The Common Council of Jamestown, N.Y., will allow the street railway company to change from horses to electric traction, and grants concessions of further streets, in return for which the city will receive 3 per cent. of the gross receipts. In Chicago the electric railway along Ninety-fifth street will be built mainly by the property owners along the route, who are to pay a bonus of 10,000dols. a mile.

Telephone Tenders for Spain.—The Spanish Government has published the conditions under which tenders will be received for the construction and working during a certain number of years of a complete network of telephonic lines to be established between the principal towns in Spain For this purpose the country will be divided into four districts. Telephonic communication must be established between the principal towns designated in each district within 10 months after the date of the concession; with other towns of less importance within a year from the same date, and with other places within three years. All the apparatus employed must be of the most perfect description. The maximum charges to the public are fixed by Government, and the holders of the concessions will pay an annual sum to the State for each kilometre of line. The full conditions under which tenders will be received are published in the *Madrid Gazette*.

Newark.—At the meeting of the Newark Sanitary Authority on Monday, Mr. Norledge proposed that the Lighting Committee consider the advisability of supplying the town with electric light, and of adopting the Electric Light Act. He said the application of the electric light to Newark would not be a difficult matter, owing to the fact that there was cheap motive power in the town, which many towns did not possess. The subject was one, therefore, that was well worthy of serious consideration. The ex-Mayor seconded the motion, and thought it was a pity that the Corporation should lose any opportunity of acquiring the power to supply the town with the electric light. Mr. Norledge said if they did not adopt the Act it would be open to any private company to come and adopt it upon certain terms. It would be better to have the reins in their own hands than to leave it to private speculation. The motion was agreed to.

Peculiar Accident.—A serious accident occurred at the electric light installation of the Electric Construction Corporation, near the Mansion House, one day last week. Peculiar fluctuations having been noticed in the light, Mr. M. J. M. Williams, one of their electrical engineers, went to the engine-house to ascertain the cause, and found the two men who had charge of the installation lying on the floor in an insensible condition, having been overcome by the gas escaping from the gas engines which drive the dynamos. Mr. Williams, in trying to restore them to consciousness, was himself overcome, and when shortly afterwards Mr. Frank King, chief electrical engineer, entered he found all three on the ground in a helpless condition, and he also soon became seriously affected by the poisonous fumes. An alarm was given, however, and all the sufferers were removed to St. Bartholomew's Hospital, where they remain. Mr. Williams was reported to be in a very serious condition.

Chicago Exhibition.—The site for the 1893 World's Fair at Chicago is of fully 1,000 acres. Ground was broken in January this year, and work on the buildings will commence in the spring. The machinery hall will be the largest yet built, and will furnish a large open central space admirable for display. The electric and mining exhibits are each to occupy a separate building furnished with power, and the electric hall is to be adapted, not only for power-house and light station, but for all displays and contests in manufacturing or by companies. Care will be taken to make it an object of beauty by night or day. The lighting of the whole exhibition will be by electricity, and fountain and other displays will be given. The space is already beginning to be filled up, and great care must be taken to prevent even this enormous space being inadequate. Copies of the classifications, rules and regulations, blank applications, and other information can be obtained from Hon. Geo. R. Davis, Director-General, World's Columbian Exhibition, Chicago, Illinois, U.S.A.

Underground Cables. — Several practical points arising out of the eminently practical paper by Mr. Stuart Russel, of the Silvertown Company, may be worth definite attention. In the first place, Mr. Russel said he would insist wherever possible, and thought the Board of Trade should make it compulsory, that a drawing-in system of mains should be used for all town mains. The ingenious double drawing-in high-tension mains used by the Metropolitan Company gave a double service to each house, and did away with a large number of joints. Secondly, it was not generally known also, that the Silvertown Company would send men to instruct companies' men in the making of accurate joints for not much greater cost than that of making a few joints. In the third place, cables for electric light mains should be tested and specified for in quite a different manner than at present with continued strains of high voltage. There seems to be a consensus of opinion upon this point with makers, and if a few of the large makers were separately or in combination to draw up what they consider a model test and specification, we shall be glad to give prominence to the subject.

Belgrade.—The Municipality of Belgrade are inviting tenders and schemes for the electric lighting of the town. The following is the gist of the conditions: The public streets (about 38 miles) to be lighted entirely by electric light—arc or incandescent; current to be furnished by steam engines. First-class roads (4½ miles) are to be lighted by arc lamps, the remainder by 1,000 incandescent lamps 35, 50, 60, and 70 yards apart (a plan can be obtained showing the position of each lamp). The intensity of the arc lamps will be 10,000 c.p., and the incandescents 16 c.p., measured. The system may be by alternate or continuous currents. Overhead wires may be employed in all cases where their presence causes no danger. The lighting of public buildings will necessitate about 3,000 lamps of 8 c.p. and 16 c.p.; the number of private lamps cannot be closely estimated. The concession will be for 41 years, at the end of which time the whole central station and mains and apparatus will become the property of the Municipality. Conditions to be stated by which this can be done after 16 or 26 years. Half the public lamps to be kept alight all night, and the other half till eleven at night; 2,500 hours for the first mentioned will be guaranteed, the duration of the second category will vary according to season. The undertaker is to indicate the price for public and private lamps and the discount for large quantities. The current is to be on day and night at all hours. The central station will be near the railway station. Those tendering are to submit plan of station and indicate the sum which they are disposed to deposit as guarantee. The tenders are to be sent to the Mairie, Belgrade, Servia, by 13th April, 1891.

Portsmouth.—Last session the Portsmouth Town Council obtained a provisional order investing them with powers to light the borough by electricity, and a short time ago they set the Electric Lighting Committee to work to consider the question of introducing the light. Their first step was to consult Mr. J. N. Shoolbred, who recommended them to visit Bradford, to inspect the low-tension system which had been installed there under his directions. Five of the members paid the borough a visit, and returned very favourably impressed with all they saw and heard, with the result that the committee recommended at the last meeting of the Council that the electric lighting of the borough be carried out by the Corporation, and that Mr. Shoolbred be engaged to prepare plans and specifications. In moving the adoption of the report, Mr. G. Ellis stated that the cost of the electric light would virtually be 4s. 6d. as against the present price of gas. Mr. S. Foster seconded the motion. He admitted that for many years to come they might work at a loss; but they would have the satisfaction of knowing that they had the matter in their own hands. At Bradford the loss in the first half-year was £1,079, in the second £732, in the third £315, and now the profit was £17. Mr. Ward suggested that the committee should engage Mr. Shoolbred to visit the places where the electric light would be supplied, and to furnish a report as to the probable cost, and he proposed that as an amendment. This having been seconded, Alderman Blake expressed the opinion that it would be hard to throw over a report of a committee who had devoted so much time and attention to the subject, and he suggested that it should be altered to meet the views of the mover and seconder of the resolution. This was done, and the amendment was then carried unanimously, the alteration providing for the bringing up of a report as proposed.

Alternate-Current Transmission.—We understand that the three-wire alternate-current motor system recently patented by the Allgemeine Company is ready for general practical application. The rotary electrical phase system realises the desires of engineers for the utilisation of the waste power from waterfalls and rivers. The chief point of attraction in the Frankfort Exhibition will be the enormous transmission of power from Lauffen to Frankfort, which will be carried out by means of this rotary phase system of the Allgemeine Company. The utilisation of the falls of the Rhine at Rheinfelden will also be carried out upon this system for supplying Basle and the neighbourhood with light and power. Plant for still larger transmission of power at Heilbronn is being erected, and we have already alluded to the transmission from Bülach to Oerlikon, at Zurich, for the Oerlikon Works, who have the license of patents from the Allgemeine Company for Switzerland. These rotary phase motors are distinguished by their surprising simplicity when compared with other motors yet devised. They require no special attendance, have no brushes, make no disagreeable noise, and keep a constant speed. This alternating motor will, it is expected, prove a far greater friend to the small workman than the gas motor, being simpler, easier to manage, and less costly to buy and drive. In the cottage industries of the Thuringian Forest and the Erzegebirge it is expected great use will be made of the new system. There are a large number of natural reservoirs and falls of water which can be utilised, and the power distributed by mere telegraph wires at high pressure. While so much attention is being given to this most important invention in Germany it is quite time we had an example of this system tested in England, and arrangements made for the erection of a practical plant on sufficient scale to demonstrate to our engineers the overwhelming importance of the exhibit which is being brought forward at the Frankfort Exhibition.

Sudden Diminution of Resistance.—An account of some extremely curious experiments carried out by M. *Ed. Branly, professeur* de l'Institut Catholique, is given by F. Kéramon in *Cosmos* (14 March), upon the extraordinary diminution of electrical resistance in certain bodies occurring after the passage of a single spark from an induction machine in air anywhere in the neighbourhood. The resistances used were composed of plates covered with a thin coating of fine metal or afterwards of columns of filings of various metals. The plates constitute conductors of resistance variable within very wide limits by means of mechanical compression. What M. Branly points out is that when a cell and a fine-wire galvanometer is attached to these, the resulting current being extremely small, if in the neighbourhood a spark is drawn from an electrical machine, the resistance of the column falls suddenly from several millions of ohms to a few thousands or even to a few hundred ohms. A tube of filings will thus have its resistance diminished by a spark from a machine many yards or even two or three rooms away. M. Branly has discovered that other dielectrics, for instance, air, are thus modified: a paste made of Canada balsam, salt water, and metal filings will drop from several millions of ohms to a few hundreds at one spark, and so remain sometimes for over 48 hours. One of the most noticeable experiments is as follows: Two rods of copper are oxidised in a Bunsen flame, crossed and pressed together by weights to avoid variations of resistance by shaking, and connected respectively to the terminals of a Wheatstone bridge. A resistance (taken at hazard out of a number) will be, say, 80,000 ohms. After a spark has passed between the knobs of an independent electric machine anywhere in the vicinity, this resistance will drop to 70 ohms. These experiments will doubtless interest our readers, and some of them may be in a position to repeat and test and theorise upon them. We merely abstract from a long illustrated article, in which details are fully given.

Mr. Holroyd Smith on Electric Traction.—At the meeting of the Royal Scottish Society of Arts held in Edinburgh on Monday, Lord Kinsburgh presiding, Mr. M. Holroyd Smith, Halifax, read a paper on "Electric Traction." In his introductory remarks, Mr. Smith gave some explanation of the phenomena attending electric action, and enlarged upon their value and utility. He contrasted the steam engine and the electric motor, and instanced among the other practical advantages of the former not often realised the absence of waste in the case of an attempted start where movement was impossible. With the electric motor, on the other hand, when the current was turned on and movement was impossible, the whole machine—unless some safety devices were introduced—would be burned up. After describing how to use and apply electricity he entered into the question of how the electricity was to be produced and supplied, and showed that the so-called accumulators or secondary batteries were never likely to be economically useful. He emphatically asserted that until a battery altogether different from any existing one, and at present unknown to electrical science, had been evolved, tramcar propulsion by such a means could not compete with horses. He then went on to show that when the electric energy was supplied direct from a generating station the work could not only be successfully, but economically done; and gave some figures indicating the enormous strides made in America in street railway traffic. There were, he said, 319 electric tramways in operation in America—2,371 miles of track, and 3,749 electrical tramcars—representing, in all, an aggregate of over 200,000 h.p. In conclusion, Mr. Smith showed that batteries were the most attractive, but the most expensive and troublesome, and could not be made to pay; that overhead lines were the simplest and cheapest, but were objected to on account of their appearance and attendant risk; and thirdly, that underground channels were more expensive to construct than overhead conductors, but less costly than batteries, and when properly constructed were the best and safest and most reliable.

Interior Conduits.—A report has been made by a committee of the Franklin Institute, of which Carl Hering was chairman, and is issued in the March number of their *Journal*, upon the system of house wiring by means of interior conduits or pipes placed in the walls or plaster of houses, through which the electric light wires are afterwards drawn. It consists, in general, of a system of continuous tubes of insulating material, the wires being insulated electrically from the materials of the building, while the woodwork is also protected from being ignited by the accidental heating or short-circuiting of the wires themselves. The tubes are made of paper or similar material heated and soaked in a very hot bath (460deg. F.) of bituminous compounds. The tubes are made in various sizes from ¼in. to 1½in. diameter. They are hard, strong, and tough, and are made fireproof, when necessary, by a coating of fireproof paint on the outside; they cannot be ignited from the inside, from the want of sufficient air to support combustion. They are thus, in this sense, fireproof, though made of combustible material. They are claimed to be waterproof except at joints, and can be made absolutely so by being encased in lead pipes. They are secured by a simple brass clip to the walls. The centre of distribution in housework from which they are led is chosen about 35ft. from the outlets. For underground work they can be enclosed in an iron box filled with insulating compound. The wires are pulled through by a pilot wire or string, five bends being the limit through which insulated wires can be drawn. The system admits of houses being prepared before the exact system of lighting is determined upon, and wires can be easily withdrawn and replaced. For large mains separate tubes are used for positive and negative, but for smaller branches the two wires are run in the same tubes. The wires when double or single have merely a light textile insulation instead of expensive insulation. Experiments were made by the committee which tended to show that no danger arises from such simple insulation. A slight leak made by moisture was found to char and set fire to wood on wires run in wood casings, but when a similar leak was made in the interior conduits the fuses went at once. In another experiment overloaded wires set fire to wood, but the tube was not found hot enough to do any harm. The committee consider the invention of importance and value, and recommend the award of the John Scott Legacy Medal and Premium. Mr. E. H. Johnson described the same system in a paper before the Franklin Institute, in which he stated the system is nothing more or less than a well worked-out scheme of supplanting or supplementing the former practice of attaching the insulation to the wire itself by a system of insulated race-ways, into which are drawn the wires, high and durable insulation and accessibility being thereby attained. He says it is not too much to claim that it can be installed even more cheaply than ordinary insulated wires. The company have developed a whole system for underground conduits, with manholes and with lamppost and branch taps, constructed as to be simply minor extensions of the system. They feel free to express their conviction that in point of first cost, durability, flexibility, insulation, cleanliness, economy of maintenance, and general adaptability, no other combination of underground conduit and conductors can even approximately equal this system.

Centrifugal Action.—In the discussion before the Institution of Engineers and Shipbuilders in Scotland, on Feb. 24, upon Mr. John Laidlaw's paper on "Centrifugal Action in Practical Work," some interesting remarks were made with reference to dynamos. Prof. Barr referred to the effect centrifugal action had in Mr. Parsons's electrical generator. That machine may run up to 20,000 revolutions per minute, and then the difficulty of balancing comes to be excessively great. The smallest want of balance will produce disastrous effects, and Mr. Parsons had to devise special means of getting over it. He designed the bearings of the steam turbine in such a way that it can take its own axis of revolution instead of being constrained to revolve about a fixed axis. This necessitates some clearance between the turbine and its case, which causes a leakage of steam. The centrifugal action is therefore a source of considerable—indeed, the principle source of loss—loss of efficiency in the turbine. The question of the balancing of revolving bodies is not the same as that of balancing them statically about the axis of rotation. Suppose we have an axis carrying a weight of one at a distance of two at one end, and a weight of two at a distance of one at the other end, that will make a perfect balance so far as moments about the axis are concerned, but it will not make a perfect balance in the direction of the length of the axis, and there will be a tendency when it is running for it to change the axis of rotation. It was for these reasons that Mr. Parsons devised a special method of supporting his turbine shaft. Prof. Barr mentioned a case which occurred at Greenock about five years ago, where he happened to be called in to inspect and report upon some electric lighting plant. When the plant was first started the countershafting, which was supported from the rafters of the building, caused such an amount of vibration, noise, and heating of the bearings, that it appeared positively dangerous to remain inside the place. Upon careful examination, however, he found that the mechanic who had made and erected the shafting had never even thought of balancing the pulleys, and it was with great difficulty that he got him persuaded to take the whole down and balance it carefully on parallel straight edges. On being re-erected and set to work again, it ran smoothly and without any observable heating at the bearings. What the mechanic wanted to do was to shore up and to stiffen the rafters so as to keep the wild beast called "unbalanced centrifugal force" within bounds, instead of preventing its appearance and capers. Mr. Thom suggested the possibility of arranging a flywheel on board ship big enough and driven fast enough to prevent rolling. Prof. Barr said he would refer him to a formula by Sir William Thomson, devised for the purpose of enabling engineers to calculate the stresses on the bearings of ships' dynamos ("Electrical Rules and Tables," seventh edition, page 408, published by Chas. Griffin and Co., London). It was a fact that when the electric lighting of steamers was first introduced, engineers had omitted to recognise the necessity of placing the plane of the rotation of the armatures athwart ships, in order to avoid, as far as possible, wear and tear of their bearings due to the gyrostatic action. The old type of alternate-current dynamos having heavy armatures of large diameters, driven at a high speed, had given great trouble from this cause, often necessitating a complete renewal of their bearings. This gyrostatic phenomenon is now, however, well recognised, and, as a consequence, slow-speed dynamos properly placed are usually specified for steamers. If engineers generally would lay to heart the recommendations given by Mr. Laidlaw in his paper, there would not only be far less vibration, noise, wear, and tear, but more efficient fast-speed machinery.

UNDERGROUND MAINS.—V.

THE BROOKS SYSTEM.

(Concluded from page 256.)

The general scheme of the use of the Brooks system for public lighting at Hong Kong is shown in Fig. 9, where the overhead lines are seen coming to tall posts bearing insulators with an arc lamp above the wires. In the crowded streets, where overhead wires would not be advisable, the high-pressure wires for the arc lamps in series, carrying 2,000 volts, are taken down and under the streets in iron pipes filled with the Brooks liquid insulation, are then run along the streets and up a series of lampposts—one of which is shown in the illustration—and then up vertical pipes again to the overhead wires.

The details of the junction-box and insulator for the top of the posts, where the overhead and underground wires are connected, have been carefully worked out by Messrs. Johnson and Phillips, and are shown in Fig. 10. The wires are pulled through the box, and the ends soldered together and insulated, and a screw cap fixed over them. The overhead line passes to an insulator specially adapted for oil insulation. The underground mains descend an ordinary pipe, and the whole is filled up with oil insulation.

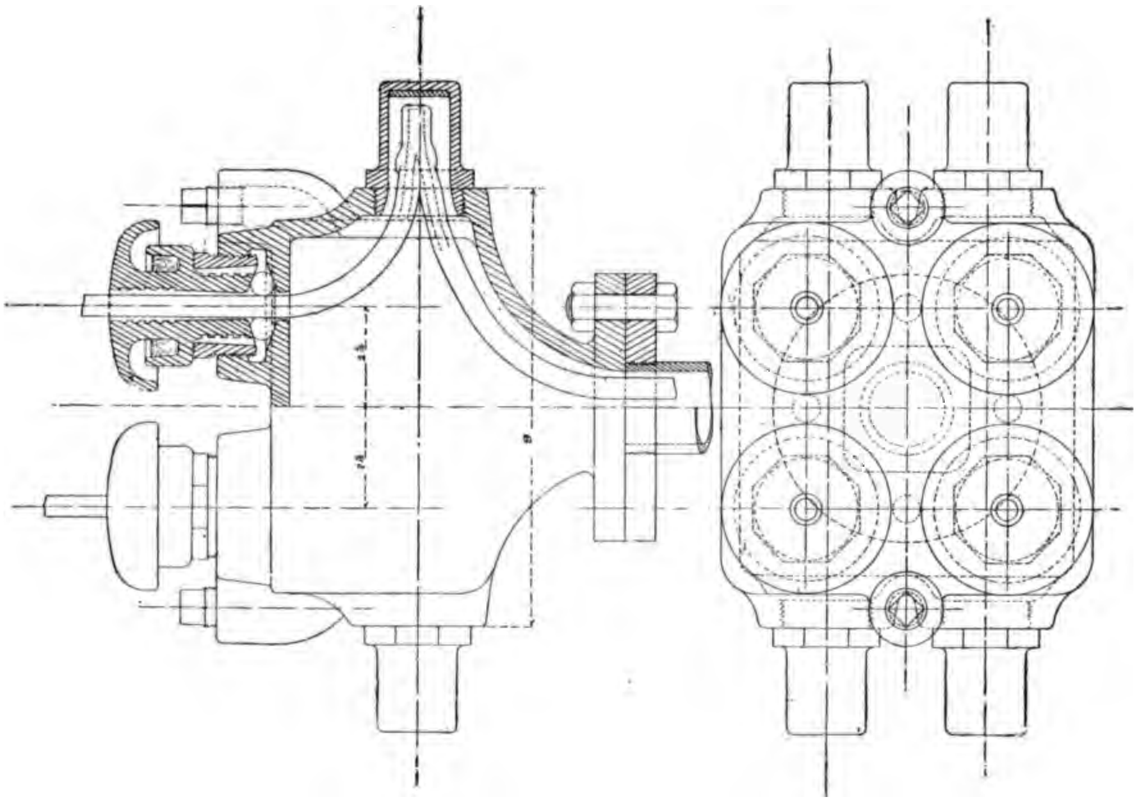


FIG. 10.—Detail of Oil Insulator on Lamp-post. Hong Kong.

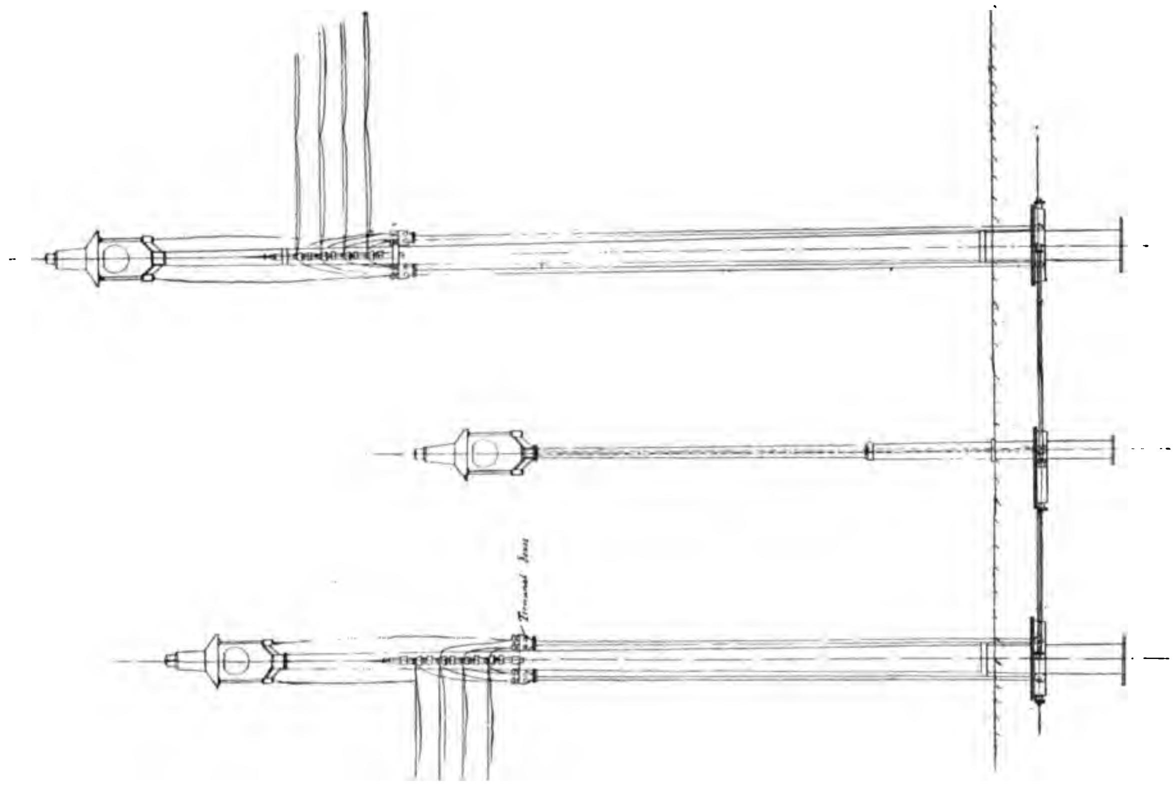


FIG. 9.—Brooks System at Hong Kong. Overhead to Underground.

We now pass to another and important application of the Brooks system.

The prominence that is being given to high-pressure three-phase alternate-current transmission in Germany and Switzerland will make doubly interesting the details of the Brooks mains which have been worked out by Messrs. Johnson and Phillips, in conjunction with Mr. Gisbert Kapp, for the underground transmission of these currents, to be used, it is expected, at an average of some 20,000 volts.

The drawings are almost self-explanatory. The junction-box, shown in Figs. 11 and 12, is for the distribution in a number of directions of the three-phase current. Each pipe contains a three-strand cable, the strands of which on entering the junction-box are separated and led through glands to separate terminals, or omnibus bars, to which the other distributing cables can be connected. Provision is made for fuses, if desired, between the mains and branches within the junction-box. Now that the enormous pressures, at

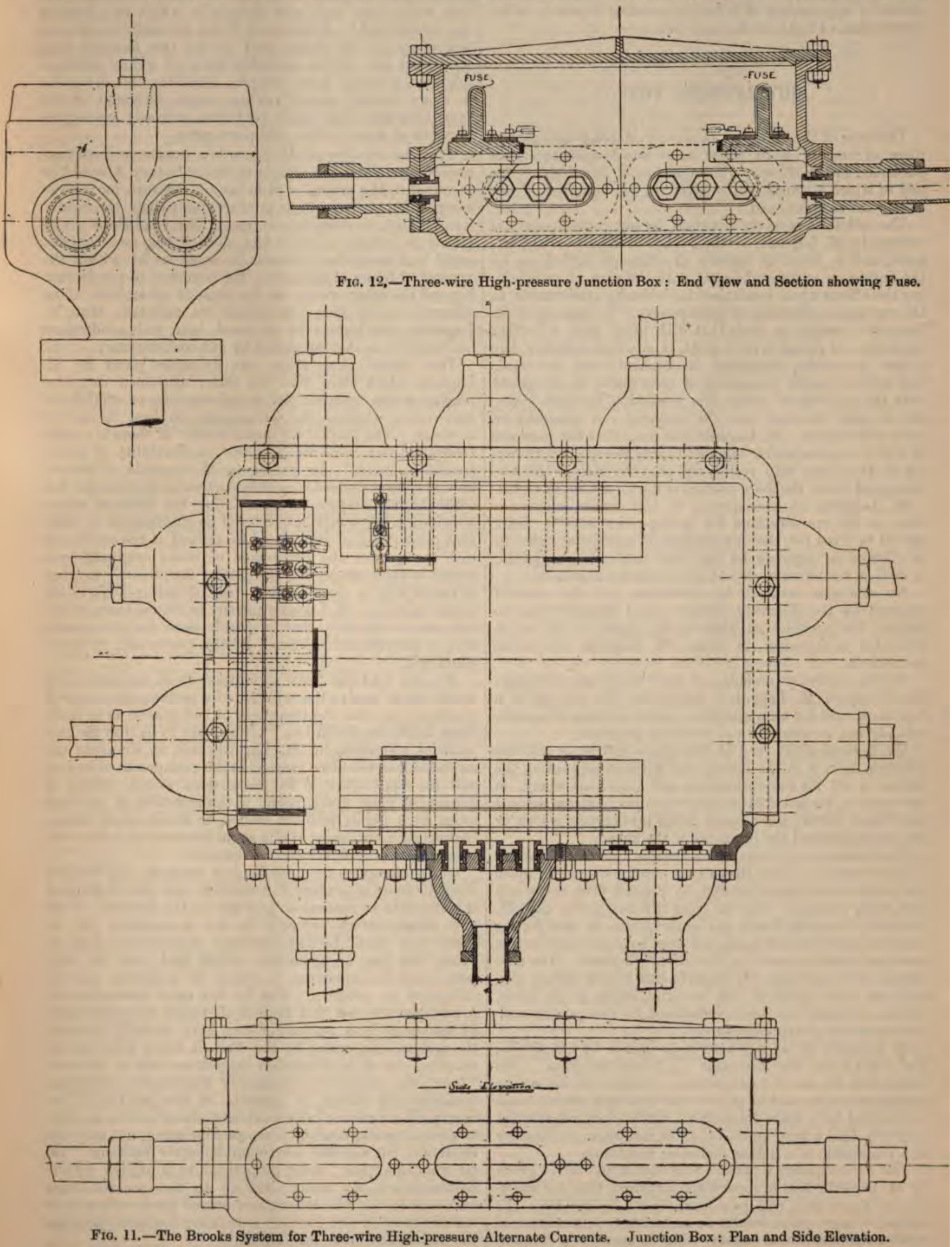


Fig. 12.—Three-wire High-pressure Junction Box: End View and Section showing Fuse.

Fig. 11.—The Brooks System for Three-wire High-pressure Alternate Currents. Junction Box: Plan and Side Elevation.

one time considered beyond control, are being handled without much greater trouble, save for insulation, than the currents of ordinary voltages, a system such as this of Mr. David Brooks should become more and more valuable to electrical engineers. We shall hope to be able to record extensive applications of it for transmission of power, or for distribution of light, in the near future.

GUTTAPERCHA CORE.

The issue of the *Electrical Review* for March 6 devotes the place of honour in its pages to an attack upon an article published in the *Annales Télégraphiques* of Jan.-Feb., 1891, and of which a translation is given in the number of the *Review* above mentioned.

The article so severely criticised by our contemporary is written by M. Lagarde, of the French Telegraphic Department, and it describes certain experiments carried out by the author on guttapercha core, with the view of ascertaining the effects upon insulation individually attributable to the various constituents of guttapercha. To summarise M. Lagarde's results, he finds that with more than a certain proportion of resins to pure gutta, in any core, a higher, but a less permanent, insulation is obtained; and, *vice versâ*, that with a quarter percentage of pure gutta, as compared with the quantity of resins the insulation becomes lower, but is more constant, and the material can generally be more relied upon. M. Lagarde also finds that the presence of water in guttapercha assists towards the gradual changing of the gutta into resins, and that the greater the percentage of water the more marked is the formation of resins.

M. Lagarde, in consequence of the results, advocates that in all specifications for guttapercha core a limit should be fixed for the percentages of resins and water to be allowed in guttapercha, and that maximum insulation, as well as a minimum, should invariably be stipulated.

No one can cavil at fair criticism, but the method adopted by the *Electrical Review* would certainly lead to suspect the presence of what would appear to be an uncalled-for antagonism to either M. Lagarde or to his deductions.

We can perfectly understand why many manufacturers should oppose M. Lagarde's suggestions, but we are at a loss to account for an opposition, in the columns of a scientific journal, to scientific and technical progress.

We have carefully read M. Lagarde's article, as also the criticism upon it in the *Review*, and without supporting the former in all his contentions, we will point out where, in our opinion, his critic, in his anxiety to prove a case against the French official, has himself fallen into certain errors, or has misunderstood the intention of the author.

Our contemporary asks us to believe that M. Lagarde's article "tends to prove that all, or nearly all, cables up to the present time manufactured by English firms are worth absolutely nothing." So far from this being the case, M. Lagarde distinctly limits his observations to core he has actually experimented upon, nor does he state whether this core was manufactured in France or England. The conclusion he draws from his experiments is that certain precautions, with regard to the material, ought to be taken, and he evidently has been influenced by the present conditions of the guttapercha supply.

M. Lagarde in no way asserts, as stated by the *Review*, that "the lower the insulation the better the gutta." He shews that the less the proportions of resins the better the guttapercha core, and he points out that this circumstance is attended by a lower insulation; but he does not attempt to prove that a pure gutta of a low insulation, is superior to a pure gutta of a higher dielectric resistance.

The *Review* quotes a portion from one of the tables given by M. Lagarde, and is apparently surprised that a diminution of 8 per cent. (we reproduce these figures from the *Review*) of pure gutta results in an increase in insulation of 1,100 megohms in one factory, while in another a diminution of 3 per cent. produces an increase in dielectric resistance of only 600 megohms. Again, two perchas are compared, one coming from each of the aforesaid factories. They are almost identical in the percentage of water, resins, and pure gutta, but there is a difference of 60 per cent. in the respective insulations. From these figures our contemporary comes to the conclusion that "the relation said to exist between chemical analysis and specific insulation resistance holds good only when one remains within the four walls of the particular factory in which this relation was established." Presumably it did not occur to our contemporary that the guttas used in the two factories may have been, and, indeed, probably were, of widely different qualities, obtained from different localities, and dissimilar in every respect, except perhaps name, although at the same time they may have contained precisely equal proportions of water, resins, and pure gutta.

From his reading of M. Lagarde's results our contemporary formulates the complaint that "factory A would be favoured to the prejudice of factory B, because, for a given composition of its gutta, it produces only half the insulation." Such a reasoning is, under the conditions given, purely a *reductio ad absurdum*, since if the two factories could both work their guttapercha so as to be within the prescribed limits of insulation, the favouring of one factory beyond the other would be for reasons other than those adverted to by the *Review*, and we maintain that M. Lagarde's conclusions in no sense bear such a ridiculous construction as that suggested by our contemporary.

The *Review* then takes two examples given by M. Lagarde which show that the water contained in guttapercha assists towards the transformation of the latter into resins, whether the guttapercha be kept in air or in water. The journal we quote states "if there is a well-recognised fact it is the absolute unalterability of guttapercha in water." In justice to M. Lagarde, it should, however, be explained that this particular experiment was made for the purpose of ascertaining the different effects which, in time, would be produced on guttapercha by different proportions of water, and he arrived at the conclusion that the greater the percentage of water originally contained in the guttapercha, the greater the probable increase of resins with a corresponding loss of guttapercha in the course of time. M. Lagarde appears to esteem these results only as an indication that in specifications for guttapercha core, a limit should be fixed on the percentage of water contained.

We are told that "the application of M. Lagarde's law would often involve the rejection of a useful gutta, while it would not prevent the treatment of bad ones so as to make them fulfil the conditions." It appears to us that the precautions suggested by M. Lagarde seek to eliminate the imperfections too often present in the guttapercha of to-day, and the application of his restrictions would, instead of penalising good gutta, result in the rejection of low-class gums of a highly resinous nature, or would, at all events, necessitate a treatment which should remove or reduce the proportions of undesirable constituents.

Our contemporary vaunts English methods, and invokes their 40 years of practice to convict as rash and ill-directed the attempts at innovation pursued by the French. Were our contemporary correct in his assumption as to what has been English practice during the last 40 years, his line of argument would lead one to suppose that he approved a policy of inactivity and indifference to progress. But he has most unaccountably overlooked the fact that English engineers, whose example he recommends to our neighbours, have actually followed the system inaugurated by the French many years ago in adopting one of M. Lagarde's suggestions, one of the very "laws" the *Review* so vehemently condemns; surely our contemporary cannot be ignorant of the fact that all, or nearly all, submarine cable contracts offered in this country to general tender contain a clause stipulating, not only the minimum, but also the maximum dielectric resistance. So far from this "law" being prejudicial, as is argued by our contemporary, no reason has up to the present been advanced for its withdrawal, and indeed the tendency is in the direction of still further narrowing the limits between the higher and lower insulations.

Not only in this respect, however, have the French been before us, for it must be admitted that in scientific investigation they also give us an example which might well be followed. Guttapercha has in its turn been long the subject of experimental research, and their Administration has in many ways encouraged the enquiries of its officials in this direction. Perhaps we are more practical, perhaps we possess to a greater degree the faculty of making immediate and commercial use of what we do discover; but we must give our neighbours due credit for their particular merits, and it is incontrovertible that M. Lagarde, though possibly not accurate in all his deductions, has certainly been working in the right direction, and anyone who has studied the pages of the *Annales Télégraphiques* must be convinced that he is an able and painstaking observer.

In conclusion, we would express some surprise that a journal which has been remarkable, among other electro-technical publications, for the particular attention it has paid to questions affecting submarine cables, should have advocated a doctrine so opposed, in our humble opinion, to progress in the method of treating a material which is daily becoming more difficult to handle with success, and which consequently demands greater attention and more careful management. As we before suggested, manufacturers may perhaps look at the matter from a different point of view, and they may very naturally object to such stipulations in their contracts as may entail greater vigilance and increased expense, together with a better knowledge of the material in course of manufacture.

SOME RECENT IMPROVEMENTS IN LEAD SECONDARY BATTERIES.*

BY J. T. NIBLETT, MEMBER.

The object of the present paper is to point out some of the recent improvements in lead accumulators or storers of electrical energy.

On the introduction of the Planté cell, and its subsequent development by Faure and others, much attention was given to the chemical and electrolytic action of an electric current on the elements during their formation, and also during their charge and discharge.

Dr. J. H. Gladstone and Prof. A. Tribe, in some communications to *Nature* on January 5, March 16, July 13, and October 19, of 1882, and April 19, of 1883, have gone most carefully and ably into the subject of the chemistry of accumulator cells. Much, also, has been written on this subject by Messrs. Reckenzaun, Desmond FitzGerald, Frankland, and many others. A very valuable addition to the literature of this important subject has been recently made by two papers, entitled "Notes on the Chemistry of Secondary Cells," and "The Working Efficiency of Secondary Cells," by Prof. W. E. Ayrton, and Messrs. Lamb, Smith, and Woods.

Although the precise nature of the chemical changes involved in a lead sulphuric-acid cell due to the action of an electric current are not yet fully established, enough is now known to enable those concerned in their commercial manufacture to construct cells of almost any capacity, and capable of giving any rate of discharge. It is now usual to speak of any given type of storage cells as being of so many ampere-hours capacity per pound of plates, or per pound of cell. In the latter case, the precise nature of the electrolyte, and also whether the containing vessel is of glass, earthenware, metal, or wood, must, of course, be specified.

Since the year 1880, some 700 applications for British letters patent have been made for improvements in electric accumulators, and of these some hundreds have developed into full published patents. The great majority of the suggested improvements are of a mechanical nature, and relate more especially to (1) methods of accelerating the "formation" of the elements; (2) means of preventing the disintegration of the "active" material; and (3) attempts to prevent that great bugbear of all lead accumulators—the warping and buckling of the plates or grids.

Although it would be quite impossible in a communication of this description to notice all the ingenious attempts which have been made to overcome the above-mentioned difficulties, I will endeavour to point out some of the improvements which at the present time appear to be meeting with most favour.

Lead storage batteries may be divided into two classes—viz., those in which the active material is formed from the substance of the element itself, either by direct chemical or electro-chemical action, and those in which the chemical formation is accelerated by the application of some easily reducible salt of lead. Elements of the former type are usually called "Planté," and those of the latter, "Faure," or "pasted."

Although earlier experimentalists are known to have found that certain substances, when subjected to the action of an electric current in an electrolysable solution, have been found to store electrical energy, Gaston Planté seems to have been the first to thoroughly appreciate the importance of this phenomenon; and there really seems to be some doubt as to whether he did not anticipate Camile Faure in foreseeing the great economy to be gained in point of time by applying salts of lead to the unformed lead plates. R. Jamins, in his work entitled "Recherches sur les Accumulators Electriques," says, "Le grand inconvénience de la pile Planté reside . . . . dans la longue durée exigée pour sa formation. M. Planté avait bien supposé qu'en deposant du minium sur les electrodes en plomb, il reduisait le temp de la formation de ses couples; mais il ne parvint jamais a donner un adhérence suffisante au minium que recaillais et finissait par disparaitré." Again, Jablochkoff in a provisional application for a patent, No. 1745, of 1881, says, "M. Gaston Planté proposed to apply to the metal or other electrodes (in a secondary battery) a layer of oxide, rendering the surface both rough and porous." On going carefully through Mr. Bedford Elwell's admirable translation of Planté's "Recherches sur l'Electricité," no mention was found of any process of applying an oxide to storage-battery elements for the purpose of rendering them rough and porous, nor were the alleged troubles experienced by Planté in causing the oxides to adhere to his plates, referred to.

Planté's Original Secondary Cell.—Planté's first lead elements were of an extremely simple nature, consisting merely of two long strips of thin sheet lead placed one upon the other. To prevent metallic contact between the lead strips, a long piece of coarse cloth or felt was placed between the two plates. This compound plate was then rolled up into the form of a spiral, and was then immersed in a solution of one part by volume of pure sulphuric acid to 10 parts of water. The charging current was obtained from two Grove cells. It was with this form of cell that Planté made his original and brilliant experiments as described in his "Researches." The "forming" process, as suggested by Planté, was managed in this way. The current from the primary cells was caused to pass into the accumulator, until gas was freely given off from the plates. When the charging circuit was broken, a current of high intensity, but short duration, was obtained from the accumulator. On examining the elements, that plate which had been joined to the positive pole of the primary cells, was found to be coated with a thin film of peroxide of lead. The plate which had been joined to the negative pole of the primary battery was scarcely altered in appearance or in electrical properties. At each successive charging the peroxide on the positive plate sinks a little deeper into the metallic plate. This "eating in" operation goes on until a sufficient thickness of oxide is formed to protect the lead from further electrolytic action. In all cells of the Planté type little or no difficulty is experienced in forming the positive element. With the negative element the case is very different. Here the active material is chemically spongy lead, and it is only by repeatedly oxidising and deoxidising the surface of the metal, that the necessary depth of this finely-divided lead can be obtained. This, then, is the difficulty experienced in all forms of Planté cells. The usual method employed to produce the desired quantity of active spongy lead is by a system of charging, allowing to rest, and then reversing the current through the cell. By each reversal of current, the peroxide is reduced by the nascent hydrogen liberated at its surface during the decomposition of the electrolyte, first into the lower oxide, and then into metallic lead in an extremely finely-divided state. At each successive reversal the oxidising and reducing action sinks more deeply into the substance of the lead, and by careful treatment any desired depth of active material may be obtained. In practice it is found necessary to allow a period of many days, or even weeks, to elapse before a reversal of polarity is effected. It is found that unless the peroxide is allowed to assume a crystaline state before its reduction, the soft loose oxide is forced away from its metal support by the evolution of gas due to the current.

To accelerate the "formation," Planté tried a large number of experiments, the most successful being a preliminary treatment of the lead plates with very dilute nitric acid, so as to thoroughly scour and roughen the metal surfaces, and the application of heat to the cell during the formation, so as to open the pores of the metal and allow the electrolyte to penetrate more deeply into the lead.

Epstein's Method of Forming.—Epstein proposes to accelerate the formation of plain lead plates by placing them in a one per cent. solution of nitric acid and water. The solution is then heated until it boils, the boiling being continued until the lead plates have assumed a dull grey appearance, after which they are taken out of the solution and dried in the air. This treatment produces a greyish-yellow deposit of lead salts, which adheres firmly to the plates, and is insoluble in dilute sulphuric acid. In addition, it has the great advantage of being able to absorb the gases liberated in the formation process, so that the latter may proceed quickly and without the necessity of any reversals. Lead treated in this manner is made to serve for both positive and negative plates. In the process of forming positive electrodes, the former greyish-yellow colour changes into a deep dark brown, almost a bluish-black hue, and the process is completed as soon as the elements have attained that colour, and an abundant development of oxygen has taken place. The oxygen of the peroxide of lead produced on the positive elements which are to be changed to negatives, is absorbed by the effect of the electric current, and the bodies are reduced on their surface to porous metallic lead. The process of forming negative elements is finished when the deep dark brown, or bluish-black colour of the positive element used for the purpose has changed into a bluish-grey hue. It is said that only a few hours are necessary to form a plate by this method.

Schulz's Method of Accelerating Formation.—Schulz proposed coating lead electrodes of secondary batteries with a layer of sulphur, and then heating them until the sulphur combines with the lead to form a coating of lead sulphide. After being thus treated, the plates are placed in dilute sulphuric acid, and formed by the Planté process. By electrolysis the sulphur is converted into sulphuretted hydrogen and sulphurous acid gases, which escape, leaving a layer of porous lead on the electrodes.

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* Paper read before the Physical Society of the Glasgow University, 13th January, 1891.

Prof. A. Tribe's Method.—In 1884 Prof. Tribe endeavoured to hasten formation by converting the surface of lead into sulphides, arsenides, or phosphides of lead, and then reducing these salts into the form of spongy lead by electrolysis.

Monnier's Elements.—Monnier's method of making lead plates porous and easily acted upon by the electric current, was to make an alloy of lead, with about 4 per cent. of zinc. This was cast into any desired shape of plate, and was then subjected to the action of dilute sulphuric acid. When the zinc had quite dissolved out, the plates were found to be in such a condition that they could be readily converted into both positive and negative electrodes.

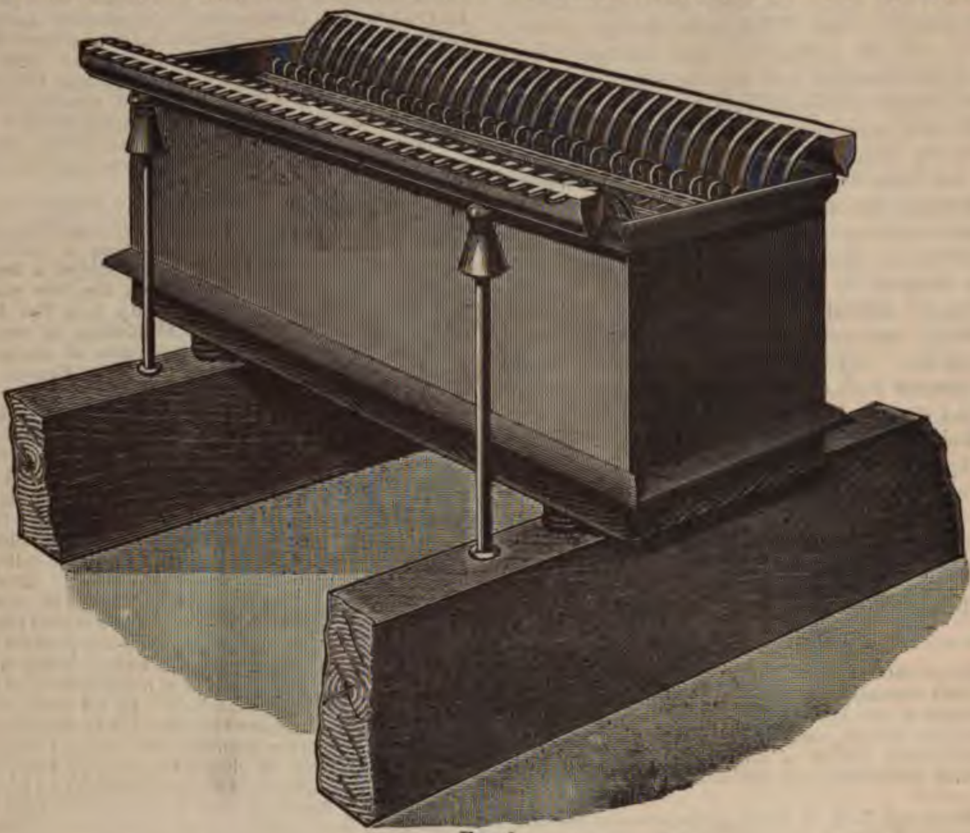

FIG. 1.

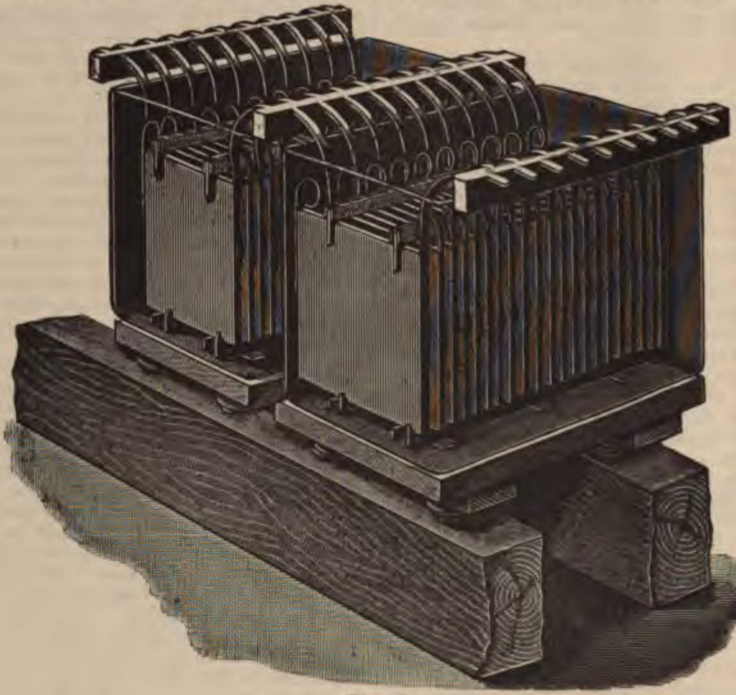

FIG 2.

Woodward Spongy Battery.—The plates or elements in these batteries are made of an alloy of lead and some easily-dissolved metal, or lead mixed with a metallic salt. The salt, or metal in the alloy, is then dissolved out by acid and water, leaving a porous mass which, it is stated, can be readily formed by the Planté method. The plates are mounted vertically in the containing cell, with the usual liquid space between each pair. Another development of this form of battery, said to be suitable for traction purposes, is made by placing the chemically porous plates horizontally, and interposing plates of porous earthenware or other suitable insulating material between them. Another form of element, due to Woodward, consists of a perforated tube made of vulcanite, guttapercha, or other non-conducting material, which is filled in with lead filings, shavings, or turnings.

Crompton-Howell Cell.—I have not succeeded in ascertaining the composition of the active material in these plates, which are of an exceedingly porous nature. It is possible that they may be prepared by some similar process to that employed by Monnier or Woodward, or made from the scum and oxides of lead formed during the process of desilverising lead. If so, a mass of this material in combination with metallic lead must be caused to cohere by subjecting it to great pressure. When formed into a hard solid block, it is evidently cut by means of a saw into suitable-sized plates. To act as a support, and also as a conductor, a leaden frame and connecting lug is cast round the porous mass. By electric formation the positive plate is converted into peroxide of lead, and the negative is reduced into the condition of spongy lead. During the forming process no reversals are required. Perforated and corrugated plates of celluloid or vulcanite are sometimes interposed between the plates to prevent buckling and consequent short-circuiting. Many of these batteries are now in use in this country for central station work, and they are also coming largely into use both for direct electric lighting and also as regulators on the main circuits. Owing to their very large active surface, this form of element is capable of maintaining a high rate of discharge. A few particulars of such a cell, capable of giving a discharge of 1,000 amperes, may possibly be of interest. The containing vessel is a lead-lined wooden trough, 4ft. 6in. long by 12in. wide and 12in. deep. In this cell (Fig. 1) are placed 61 plates of this type, each plate having an active surface on each side of about 70 square inches. Another type (Fig. 2) contains 21 plates. The width of the liquid space is 0·55in. The elements are rigidly held in position by rows of celluloid separators (Fig. 3). Two very massive lead conductors carried on earthenware insulators, run from end to end of the cell, and form the positive and negative poles. The projecting lugs from the plates are "lead-burned" into the lead conductors by means of the hydrogen-air flame. The electrolyte used is a solution of sulphuric acid and water—density about 1·250. From such a cell a rate of discharge of 1,000 amperes has been maintained for a period of 30 minutes, and without a very serious fall of potential at its poles being observed.

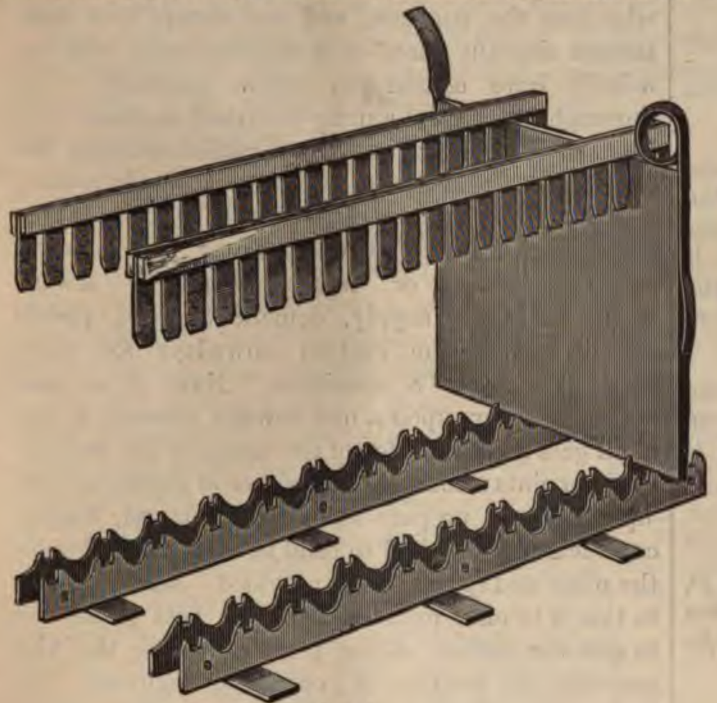

FIG. 3.

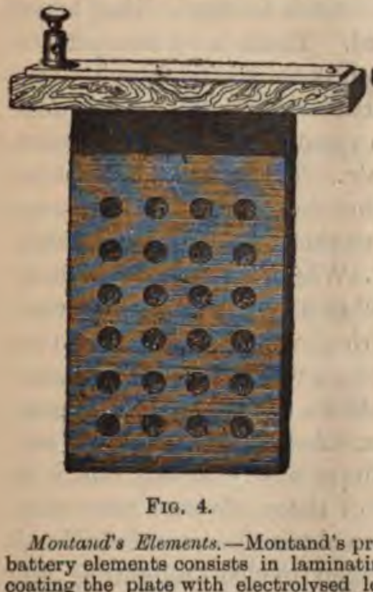

FIG. 4.

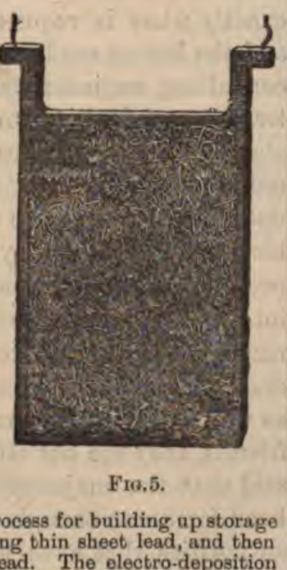

FIG. 5.

Montand's Elements.—Montand's process for building up storage battery elements consists in laminating thin sheet lead, and then coating the plate with electrolysed lead. The electro-deposition of the lead is effected in a solution of potash and water heated to about 212deg. F. A current of many hundreds of amperes is used, and the requisite thickness of deposited lead is obtained in about 30 minutes.

Tommasi Lead-Wire Plates.—Tommasi endeavoured to largely increase the active surfaces of lead plates by closely winding round them lead wires of various diameters. Sizes varying from one to two millimetres were tried.

Tommasi's idea of obtaining a large active surface within a small compass by the employment of lead wires of small diameter seems good, but in practice I believe the lead wire soon loses its mechanical strength, owing to its becoming peroxidised throughout its whole mass when under electrolytic action. As a result the active material quickly disintegrates, and soon causes the cell to become useless.

Simmen's Elements.—Of late years much attention has been given to methods of mechanically increasing the porosity of lead plates as used in storage cells, the idea being to increase the active surface, and also allow the electrolyte to penetrate into the interior of the elements. Messrs. Simmen and Reynier have given much thought, and have exhibited much ingenuity, in devising elements of this nature.

Simmen has worked out a means for cheaply manufacturing a kind of fine irregular-shaped lead wire. The wire is made by pouring highly-heated molten lead through a kind of metal cullender which has a large number of fine perforations in it. As the metal runs through these holes in fine streams it is suddenly chilled by dropping into cold water. This sudden cooling causes the surface of the wire to break up and become rough. When lead is heated in this way it is both light and porous, and is easily acted upon either chemically or electrolytically. To form elements suitable for storage batteries, he takes masses of this lead wire and then compresses it into blocks or slabs of any desired shape. These porous blocks are then placed within a perforated leaden chamber, Fig. 4. By expansion during its formation, the wire mass wedges itself tightly in the lead box. The lead box acts as a support, and also as a conductor for carrying off the current. In the complete element the electrolyte can permeate throughout its interior, and the process of transforming the raw lead into both positive and negative plates is greatly accelerated.

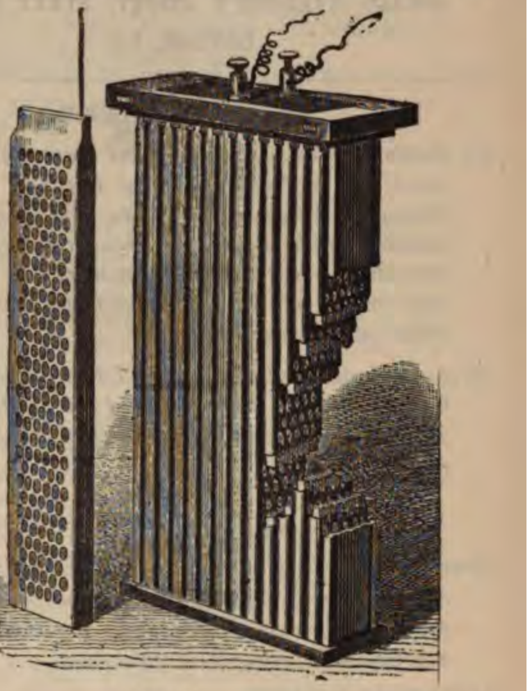

FIG. 6.

A further development in this class of plate was devised jointly by Messrs. Simmen and Reynier. In this form we have a block of highly-compressed lead wire, around which is cast a leaden frame and connecting lug, Fig. 5. It is found that with this method of preparing elements a fairly high current capacity can be obtained with only one reversal and in a very short period.

De Kabath Accumulator.—This form of accumulator cell has been somewhat extensively used in France of late years. It certainly appears to possess some substantial advantages over the early solid Planté plate. Within an outer perforated lead chamber a large number of lead strips are packed, each alternate strip being corrugated or fluted. The corrugating largely increases the amount of active surface, and it also tends to form a large number of minute cells, thereby allowing a free circulation of the electrolyte. The commercial form of cell, Fig. 6, is prepared in this way: A number of lead strips, one centimetre wide, 50 centimetres long, and about one millimetre thick, are passed between grooved rollers, by which they are corrugated in such a way that their length is reduced to 36 centimetres. Straight lengths, the same thickness and width, but 36 centimetres in length, are also prepared. A perforated lead chamber, 8·5 centimetres wide, is then made, and into this between 180 and 190 of these strips are packed, alternately a plain and then a serrated strip. A perforated lead cover soldered on then completes the box. A stout lead strip is also lead-burned into the frame for connecting purposes. The complete case now measures 38 centimetres in length, nine centimetres in width, and a little over one centimetre in thickness, the weight of each element being about 2·2lb. Twelve of these elements are then placed in a rectangular wooden box lined inside with hard rubber, which is separated from the wood by a thin coating of insulation, made by melting arkanson with some paraffin wax. The whole cell complete weighs 84lb.

M. de Kabath has written a very handy little book on the subject of accumulators, entitled "A Few Practical Remarks on the Formation and Use of Electric Accumulators." This pamphlet contains some useful information about joining up accumulators, and also several hints as to the best methods of commutating and discharging them.

(*To be continued.*)

THE

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Specimen copies of the paper will be sent on request.

THE CONTRACTOR-ENGINEER.

Our contemporary the *Contract Journal,* in its issue of this week, makes a suggestion which seems to point to the right method of solving the difficulties connected with engineers being their own contractors. The existing method of tendering for electric light work pleases nobody except the firm who gets the contract, and not always that firm. Recent flagrant cases of costly tendering pleasing nobody have caused the whole question to be thoroughly discussed among electrical engineers and contractors. So far as we can gather opinions, the universal belief is that the system is utterly rotten, and that any change must be for the better. Electrical engineering, like hydraulic engineering, or bridge work, or railway work, or sewage work, or water supply, demands special qualifications. It is the custom nowadays for every man to become a specialist. Now, if a local authority enters upon a new sewage scheme, it first of all gets a general idea of the wants of the district, then appoints a consulting engineer of repute to draw up plans and prepare a specification, and, finally, contractors are invited to send in tenders based upon the plans and specifications provided. An alternative to this is to offer premiums for the best plans, and to give the author of the plans obtaining the first premium the position of consulting engineer. We incline to the latter course of procedure for electric lighting. It gives the younger members of the profession the chances they are longing for, and it may enable them to win their spurs.

The plans having been duly prepared and adopted by the authority, tenders can be invited. Contractors are thus placed upon the same footing. They know exactly what is required. There is no favouritism, and the lowest tender can usually be accepted. The consulting engineer certifies the work of the contractor, and for his own reputation will be particular about giving a certificate. The contractor will be more particular how he does his work, because upon his obtaining the engineer's certificate depends his receiving his money. Why has the system which prevails in other branches of engineering not come into operation in electrical work? There are two reasons. One is spoken in whispers : but as someone has to pull the chestnuts out of the fire we may as well burn our fingers. According to some of our friends, they are but stumps now. At any rate, it is said that the majority of those advisers who have been fortunate enough to obtain the ear of the local authorities that have taken up electric lighting, are totally incompetent to prepare plans and specifications from an engineering point of view. That to cloak their incompetency, they have fallen into the way of asking contractors to prepare and tender on their own plans, only supplying a few general hints. Each would-be contractor has thus put forward his views, which, bluntly speaking, are simply those that he thinks will pay him best or are most likely to fall in with the idiosyncrasies of the technical adviser. The various plans are sent in, and this gentleman selects what he deems most suitable. The consensus of educated opinion may differ from him, but he selects to the best of his ability and from his limited knowledge. Besides, he learns much at the expense of those who so kindly provide plans. Most of the tenders are based upon different lines, and there can be no comparison between them. The lowest in price may be by far the dearest in the end. The other reason—no doubt fostered by interested parties—is the belief among the local authorities that there are no competent consulting engineers outside the doors of the great contracting firms, and that the existing system is thus forced upon them. Of course this is wholly incorrect. The number of competent electrical engineers is limited, yet there are sufficient to pick and choose from. Our contemporary refers to Bristol, and points out the opportunity its Town Council has to inaugurate a reform in this engineer-contractor-all-in-one business. Let this authority offer a premium for the best set of plans, and let the award be made by competent men. It would then soon be seen whether talent was wanting among our specialists, and we have no doubt the result would surprise many who incline to the opinion that there is a dearth of capable men. There would be no objection to contractors sending in plans, but the selected plans should form the basis upon which all contractors competing for the work should base their estimates.

TRANSFORMERS.

We have been so accustomed to look upon Messrs. Gaulard and Gibbs as introducing transformers for the special purpose of transforming, as to have overlooked what had previously been done in this direction. Almost every electrical phenomenon has been rediscovered by electrical students of to-day—students who never stop to enquire what the old telegraphists did; who claim credit when a little trouble would have shown that similar credit had been claimed and given before. There are telegraphists living who have the history of cable work at their fingers' ends, and who ought to lay claim to many honours that are given elsewhere. But, then, all old cable hands are and ever were a modest race. What has this to do with transformers? The history of the Atlantic cables, like some Blue-books, is invigorating reading. The promoters expected to require an electric pressure difficult to obtain with batteries, so the energetic spirits set to work to devise means to "transform upwards." The result was a closed-circuit transformer, designed, and we fancy made, by Whitehouse as long back as 1856 or 1857. One of these early transformers is now in the possession of Mr. C. E. Phillips (Messrs. Phillips Bros.), at Hackney Wick. We understand, also, that similar apparatus was employed by the Messrs. Siemens for some of the Mediterranean cables. It would be interesting to get the complete history of these "transformers," to know exactly how they were constructed, and how it was proposed to use them. It is just possible, also, that some of these early transformers may be found at Messrs. Henley's, while not long since, Mr. F. C. Webb informed us he possessed drawings of this apparatus. Perhaps some reader may be able to throw further light upon an interesting subject—for interesting it must be to find out who carried out the first practical experiments with a view to utilise for industria purposes the transforming up or down.

CORRESPONDENCE.

MANCHESTER MUTUAL TELEPHONE COMPANY.

To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Having just returned from the Continent, I notice in your issue of the 6th an article on the "Opening of the Mutual Telephone Exchange," in which you state that the transmitters are of Messrs. Siemens's manufacture.

In fairness to ourselves we wish to draw your attention to the fact that we have also supplied the Mutual with our spoon shape receivers, which have proved a decided success, and we have recently received the most flattering report from that company as to their efficiency, etc.

By kindly noting the above in your current issue, you will greatly oblige.—Yours, etc., H. OPPENHEIMER.

The International Electric Company, 34, Aldermanbury,
E.C., 23rd March, 1891.

CONCENTRIC HOUSE WIRING.

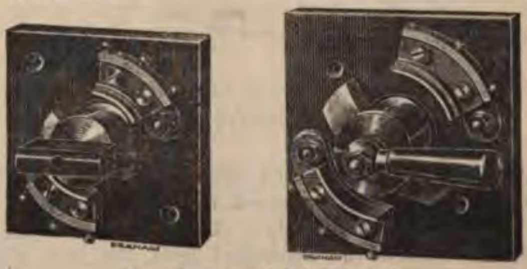
To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—In one of your recent issues there appeared a note on concentric house wiring, in which was described a novel system, with a little sensational emphasis. I imagine this has been taken from a speech made by a well-known gentleman at a recent gathering of workmen. If any novelty was to be claimed for the system it should have been brought out many years ago, as it is quite eight years since I commenced working at such a system, involving the use of tubes with a central fixed copper wire, as well as armoured concentric cables in which the armouring is one of the conductors. All the joints, switches, fuses, fittings, with swivel and universal, also ball and socket joints, have long since been worked out, and I shall be pleased to make appointments to show them to any interested party.—Yours, etc., J. D. F. ANDREWS.

41 and 42, Parliament-street, S.W.,
21st March, 1891.

ACME SWITCHES.

Some new and improved quick-break switches are being brought out by the Acme Works, improvements of Cockburn's switches, the various forms being shown in the accompanying cuts.



Acme Lamp and Main Switches.

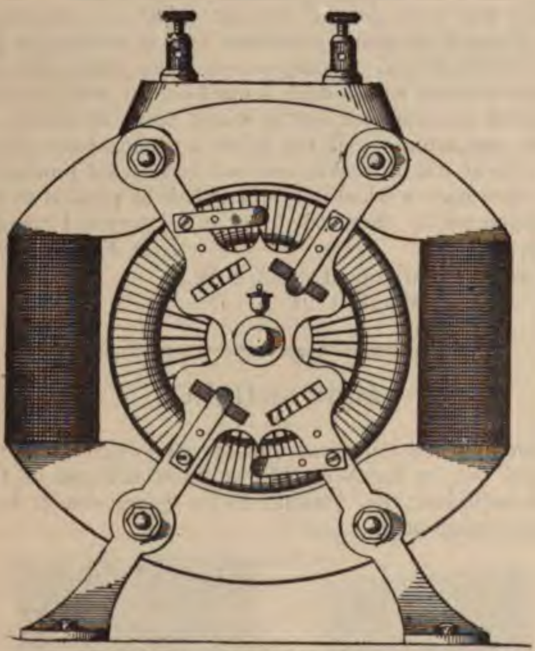
The amount of spring necessary to ensure the ends of the contact brush bedding firmly on the terminal plates is obtained by the flexibility of the brush itself, which is [illegible]structed of extremely thin rolled copper.

plates are segments of a circle, being made adjustable, and by means of screws can be so arranged as to compensate for considerable wear on the brush. They are mounted on enamelled slates, and the ends of the brush turned to a corresponding curve. The illustrations show a house switch for one to 20 lamps, and a main switch carrying up to 100 amperes. These switches are also made coupled, as in the former types, and are arranged to carry from 15 to 1,000 amperes and upwards. They are also mounted on enamelled slates for main and branch switchboards in combination with the well-known Cockburn cut-out.

Acme Double-Pole Switch.

GUTMANN'S ALTERNATE-CURRENT MOTOR.

The accompanying illustration, according to the *Electrical Engineer* (New York), shows the practical form given to this motor. The closed coil of the armature is multi-divided, and the terminals of the divisions are connected to circularly-arranged insulated plates. The supporting frame has four slots, arranged in pairs, whose members are diametrically situated, and short-circuiting brushes are retained in one pair of slots by adjustable springs. When the motor is to be reversed, the brushes are changed to the remaining slots. In the operation of the machine the brushes permanently maintain a group of the coils closed upon themselves, while simultaneously including and excluding therefrom one of the small sub-divisions at each end of the group. The sparking is slight, and the armatures poles are substantially stationary with respect to the field, while the armatures rotates continuously. An important detail of construction is that of the laminated field, the iron plates being stamped with a single die into two parts each, whose ends are interlocked, and the plates bolted together. This construction enables the coils to be wound previously on formers in a lathe, and subsequently applied to the field, thus decreasing the cost of manufacture.



Gutmann's Alternate Current Motor.

ELECTRICITY AS A RIVAL OF STEAM.

Dr. Louis Bell gave a lecture under this title before the Franklin Institute, dealing both with advanced theoretical and advanced practical considerations. We are to-day, he said, in a transition state as regards our views of electrical action. Not so long ago scientific men were content to speak of electricity as a subtle fluid, plastered, as it were, upon material things. What we really have to do with is not the indefinite thing called electricity, but a very definite thing—electrical energy. We should look upon an electrified body as a centre of a system of stresses and strains, pushes and pulls, or twists. We may sum up by thinking of electrification, not as the production of a film of electricity on the surface of a body, but as the system of stresses and strains produced around a material body by expending electrical energy upon it. When the centre of stress moves along a wire, the stresses will change; the result is a new set of stresses and strains corresponding to a spin of the medium about the direction of motion. This spin is a kind of kinetic energy—electromagnetic energy. It seems that we ought to be able to produce a similar effect by moving a charged body along, and Prof. Rowland's experiments 15 years ago showed this to be the case. If the charge were an oscillating one, the result will be a pulsating strain on the medium, still of electromagnetic spins, but intermittent. As the waves succeed, each pulse will have travelled a certain distance before the next starts. It is the marvellous fact, suspected but only proved two or three years ago, that when these are only $\frac{1}{50000}$th of an inch, they are known to us as light; and if a little longer, as radiant heat; and, finally, we come to such as would be produced by mechanical means in the alternating dynamo, where the waves would be about 2,000 miles long. If we have steady spins, the lines of force are in circles and interlock, forming a vortex: this constitutes a magnet; the addition of iron strengthens, but does not otherwise alter it to any appreciable extent. A mass of jelly twisted by a bar in its centre gives the same distribution of stress as found in certain cases of magnetisation. If we push a wire through the region of strained ether, the stresses react, and we get what we term "electromotive force," and a current flows absorbing more energy than it non-strain were there. A dynamo is nothing but a machine for dragging loops of wire through a magnetic field, and our designs are so carefully worked out that we can recover 90 per cent. of the energy used in electrical energy. We have thus an economical means of transforming energy. The steam engine is not usually well made for small sizes, which are notoriously inefficient; for instance, a 1,000-h.p. steam engine using nine-tenths of this 12 hours a day, the cost of electrical energy is almost exactly ½d. per horse-power hour including everything — attendance, interest on plant, fuel, and depreciation. In a 100-h.p. plant it will be 1½d. per horse-power hour. If the 1,000-h.p. plant only used a quarter, the cost will be 1d. per horse-power hour. It is easy to see that electric power distributed from large engines is much cheaper than small steam engines. By using electric motors there is a gain at every point. A common charge is 25s. per horse-power a month, and 5-h.p. can thus be obtained for the price of the steam engine attendant. Motors can be easily driven at 100 different points, and electric coal-cutters and drills are now coming into extensive use. We must look upon electricity, not as displacing steam, but as an enormously powerful and convenient means of transferring power with small losses. As pointed out, electricity and heat are intimately connected. When we heat a piece of iron we stir up electromagnetic energy in radiant heat, and then in light. Perhaps we may be able to utilise this some day, but as yet it is a dream of the future, and until then we must be content to go on using the present dynamos. For street car purposes it is necessary to deliver and use the energy at varying points. Steam is here almost out of the field, and the motor really does not have it for a rival. The strongest evidence of its usefulness is that nearly 300 electric roads are at work or building for running more than 2,000 miles of track. With short and heavily loaded lines the cable is as economical as electricity, but improvements are likely to reverse this, and where the line is long and not heavily loaded, the advantage is altogether on the side of electricity.

TEAGUE'S ELECTRICITY METER.

This meter, the invention of Mr. Francis Teague, manager of the Acme Works, to which we alluded last week in our description of the St. Pancras exhibition, has never been exhibited before, and embodies some points both of novelty and practicability which will make it exceedingly useful in installation work.

A general view is given of the meter in Fig. 1. It reads on Board of Trade units direct, no constant or multiplier being required.

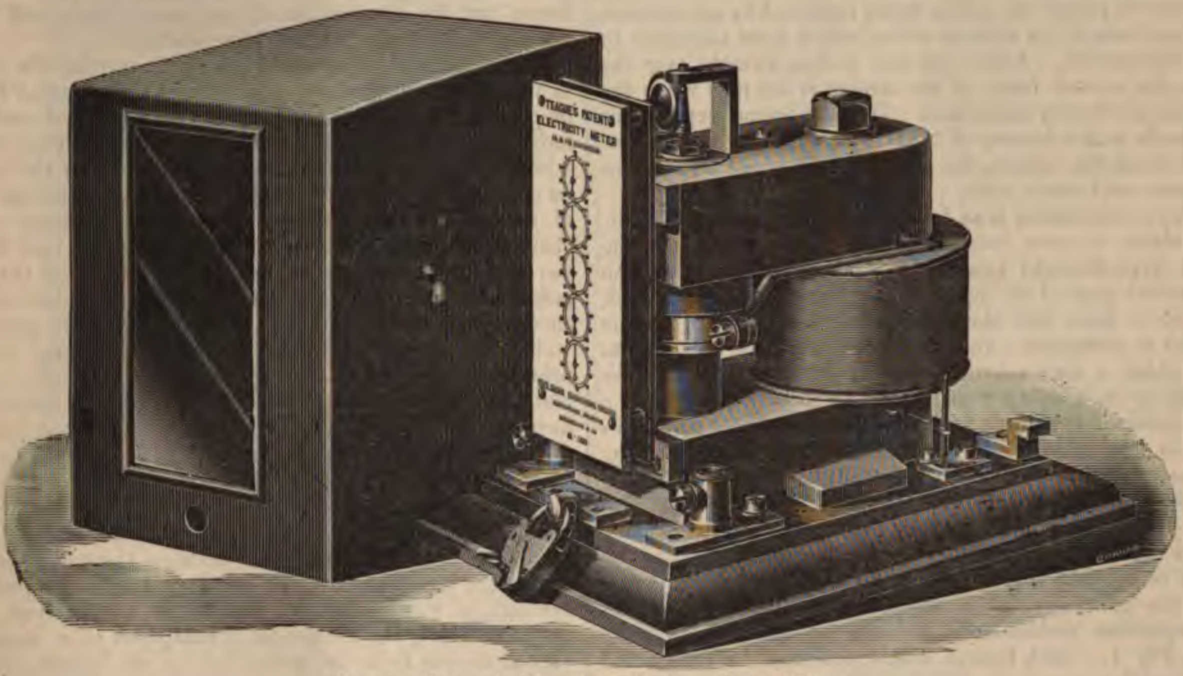


Fig. 1.—Teague's Electricity Meter. General View.

It is, in effect, a simple form of electromotor, shown in sections in Fig. 2. The armature consisting of a hollow non-magnetic cylinder—simply a copper tube, *t*—through which the current passes, contact being made by the lower edge, and end of armature and spindle dipping into a trough of mercury, *a a*, in which by a special arrangement the mercury is prevented from spilling and the action of the atmosphere reduced to a minimum.

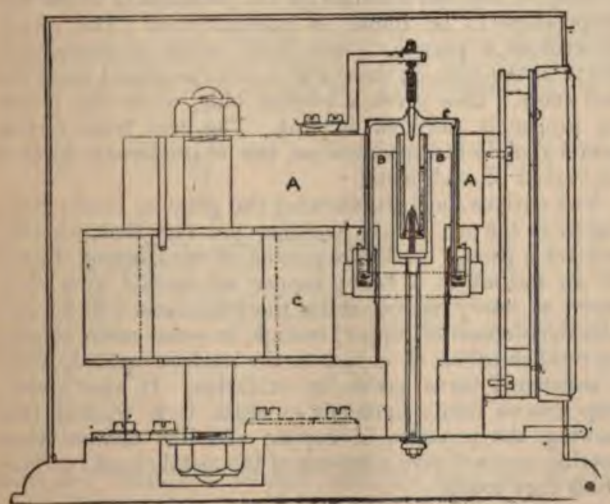


Fig. 2.—Section of Teague's Electricity Meter.

The magnet is peculiarly constructed, being so arranged that one pole, A A, is bored out, and into this hole the other pole, B B, projects almost to the top, leaving a very narrow ring all the way round in which the field is concentrated.

The armature is thus enclosed in a strong magnetic field, and rotates by the well-known Faraday disc effect, the speed being directly proportional to the current passing through the armature.

The range of the smallest size meter is from ·5 to 10 amperes, which is twentyfold, and in the larger sizes it starts with a proportionately smaller current. The magnet coil is wound with a shunt fine wire coil and one series turn. For larger currents the general size is not much increased, it being sufficient to proportionately increase the thickness of the tube and the series coil of the magnet.

The meter is so connected that a reversal of current in the mains does not produce a reversal in the direction of rotation.

The meter is now being tested by the Pall Mall Electric Light Company, and the results of these tests will be published as soon as completed.

A series of tests of reliability have been carried out by the makers during the last 18 months, which have proved that it is trustworthy, and in no way liable to get out of order, the oxidisation at contacts being nil. The total energy absorbed by the meter does not exceed five watts.

THE ELECTRIC ARC AND ITS USE IN LIGHTING.*

BY ELIHU THOMSON.

It is curious that notwithstanding the fact that as a source of illumination the electric arc has been known since the beginning of the century, the scientific study of its nature has been but little pursued. It began to be known as a sort of scientific curiosity, being at first set apart as one of the many phenomena observed in the use of powerful batteries. It was not till about 20 years after its discovery by Sir Humphry Davy that any proposals were made to use it in lighting, and, subsequently, for many years it was occasionally employed either in lecture demonstration or in obtaining an intense light for some special purpose.

The efforts to use it in lighthouses led to the designing and construction of machines on the magneto-electric principle to replace the cumbrous and costly batteries otherwise required. I remember vividly the hours of labour and time necessary to prepare a battery of 40 Bunsen cells for use in working a single small arc light for, at most, two or three hours. But I remember far more vividly the suffocating fumes and risk of acid spilling, with accompanying ruin concomitant on the taking down of a partially exhausted battery. Even to work with the arc for an hour or two was, however, adjudged a sufficient compensation for the disadvantages in obtaining the current. All this has, however, been changed, and the past 10 or 15 years has made the arc as a source of illumination one of the indispensables of a progressive community. Instead of the original sticks of boxwood or charcoal used as "points," which were only "points" because it was not expected that the arc would be burned for more than a few minutes without exhausting the battery, there came later on the little hard carbon sticks about 2in. long, and 3-16in. square, sawn from hard gas-retort carbon, or from battery plates, and lastly came the moulded and forced carbons made from a paste in a powerful press, millions of which are now required every week to keep the lamps at present in use supplied.

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* Paper read before the Providence Electric Light Convention.

The charcoal points of Davy were touched together horizontally after attachment of the wires to the battery, and were then separated. The stream of hot flame which followed or joined the points being deflected by air currents took the form of an arch or curve, which gave the name to the phenomenon. Even with one carbon directly over the other, the curved form of the stream is the rule when the carbons are widely separated. Davy's original experiment was made with a battery of 2,000 cells, with zinc and copper plates about 6in. square, the exciting fluid being very dilute sulphuric and nitric acids.

Davy's description is as follows: "When pieces of charcoal about an inch long and one-sixth of an inch in diameter were brought near each other (within the thirtieth or fortieth part of an inch) a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness; and, by withdrawing the points from each other, a constant discharge took place through the heated air in a space equal to at least 4in., producing a most brilliant ascending arch of light, broad and conical in form in the middle." This was evidently a long-flaming and horizontal arc. I find this form shown in a book published as late as 1846, Davis's "Manual of Magnetism." Indeed, I know of no more forcible example of the persistency of old ideas than is afforded by the accounts given in the books concerning the nature of the electric arc. The carbons are generally shown crusted over with dense masses of impurities melted into globules or adhering to their sides, Fig 1. Such figures would not now be recognised as resembling arcs formed with good, pure carbons, such as must be used for commercial results in arc work.

Figs. 2 to 4, inclusive, show the development at least in illustration concerning the electric arc. Fig. 2 is from Davis' "Manual," referred to.

Fig. 3 is one of the figures showing the arc, taken from Ganot's "Physics," published in 1863. Though the figure is from the seventh edition, 1886, it is virtually the former figures made vertical.

Fig. 4 is a figure of a modern arc.

In regard to the idea put forward as to the nature of the electric arc there is even a wider divergence than in the figures used for representing it. But these views are remarkable for their general accuracy or crudity, and evidently have been handed down with modifications. Few of those who have written about the electric arc, at least in the text-books, seem to have had the courage to look at the arc, or they may have seen it "through a glass darkly and not face to face." It would require too many and lengthy quotations to give these various views. In most of them the light of the arc is attributed to intensely heated carbon particles transported by the current from one pole to the other. In most of them the idea of carbon vapour as a possible factor never seems to have arisen. Others attribute the arc to the heated air between the carbons which carries carbon particles, some of which are burned.

The following quotation from a book on electric lighting, published in 1884, is a type of many such accounts: "In arc lamps, as we have already stated, the resistance which converts the current into heat is that of the heated air between the ends of two carbon rods, from one to the other of which the current passes. The light is produced by the incandescence of the ends of the carbon poles, and of the minute particles of carbon which become detached and float in the heated air between them. The heated air containing the particles of carbon forms what is called the electric arc."

Here the heated air and carbon particles floating therein are definitely stated to form the "electric arc." Nothing is said of carbon vapour having anything to do with it.

Even the statement that the positive carbon burns twice as fast as the negative is very frequently found unqualified in any way whatever. The experience of the lamp trimmer is, I need scarcely say, not in accordance therewith, the fact being that the rate of consumption, even in direct-current arcs with the same size carbon in both holders, varied sometimes quite widely from the proportion stated. However, we shall make better progress if we discard at once the older notions, and, adhering only to that modicum of truth which often accompanies error, supplant the error by the results of our own observations and experiments. My endeavour will, therefore, be to state as briefly as I can such views of the nature of the electric arc as seem to be borne out by observation during many years, and under greatly varying conditions of its production.

Let an attempt be made to separate any part of a circuit in which the current is maintained by a sufficient E.M.F. or potential, and we find that if the separated ends are moved quickly we get a flash or spark of varying length, which becomes a flame of great heating effect if the current be of large rate of flow. If the separation of the two parts of the circuit be made slowly, a continuous flame or discharge will take place between the ends if they be not too widely separated, or so widely separated that the potential or pressure of the current is not sufficient to force current across the space. With considerable potentials and heavy currents a space of many inches may thus be bridged. Whether the separated ends be of iron, copper, platinum, zinc, or other conductor, the hot discharge is still formed. Therefore, while the electric arc is generally spoken of as that flux occurring between carbon ends separated, of course, it cannot be so limited, and we frequently, therefore, refer to copper arcs, iron arcs, carbon arcs, to distinguish one from the other. What, then, is the arc so formed? Is it heated air between the ends separated containing detached particles of the conductor in process of carriage, as was apparently thought for a long time to be the case? No, the arc proper is composed of a stream of vapour arising from the actual boiling or vapourisation of the solid or fused ends of the separated conductors. In so far as the surrounding air mixes or combines with this vapour stream, it is modified by the presence of oxygen and nitrogen, but the air, or any other gas, is not essential to be present and is merely incidental to the formation of the true arc stream in air. Indeed, it may seem strange to some to speak of vapour carbon, copper, iron, platinum, etc., but their production is merely a question of temperature in any case. In the electric arc there is a real distillation of the conductors forming it, and this accounts for the variation of colour and temperature to be found in different arcs. The copper arc evolves a peculiar green light, which is exceedingly trying to the eyes, as those who have experienced its effects well know. Zinc gives a whitish blue, while the carbon arc proper is purplish in tint. The arcs from various metals give, in the spectroscope, the characteristic lines of the vapour of each metal.

As a curious incident, showing the presence of the metal vapour in the arc, I may mention the fact that when by accident a person has had a portion of his clothing bathed for an instant in a heavy copper arc caused by a short circuit of heavy current mains there has been found a considerable deposit of copper, enough, in some cases, to give the reddish colour of copper to the surface bathed, which if moistened turns green by oxidation. It also gives a deep blue to dilute ammonia in which it is washed, thus showing the presence of copper. In like manner these metallic arcs will give a deposit of the metal on cold surfaces which they touch.

It appears to be the positive pole which gives out the vapour stream. With carbon the positive vapourises steadily and is consumed much faster than the negative. In the use of the arc, however, for lighting, we have learned to distinguish between what is called a "short-arc" and a "long-arc" system. In short-arc systems the carbons are burned much nearer together than in the long-arc systems. Let us suppose the case of two carbons touching each other with a current passing, and then that we very slowly separate them, stopping to observe effects. When the contact is light, before actual separation a visible heating of the meeting ends is seen. On attaining a small separation the space between seems filled with hot vapour, and we have a short arc where the separation is perhaps not over two or three one-hundredths of an inch. There is also noted an active transfer of carbon from the flattened end of the positive and a deposition of carbon on the end of the negative carbon. This deposited carbon takes the form of a mushroom end after a time, and breaks off. Meanwhile combustion goes on at both poles, and wears away the sides of the positive carbon while the transfer of carbon wears away its tip or crater. The burning also wears away the negative at the sides, while the tip is built up by the mushroom deposit from the arc. But the cutting in of the negative finally severs the mushroom tip, and it falls away. Hence both carbons are eventually consumed. To develop a short arc there is required a little over half the potential that is needed for a long arc, or about 25 volts more or less, and therefore to give out equal heat energy in the arc the current must be doubled in the short arc over what it would be in the long arc. The short arc is subject to the objection of a continual frying sound emitted and great variations of luminosity; it requires a very dense and hard carbon to conduct the current without great loss, and involves line loss of at least four times the amount with the long arc if equal gauge wires be used.

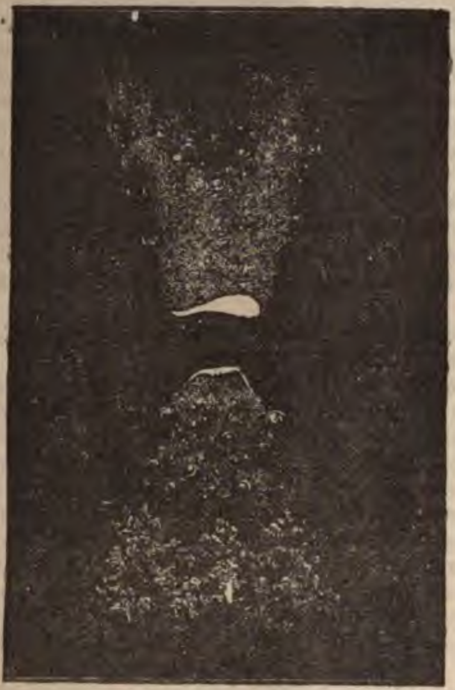


FIG. 1.

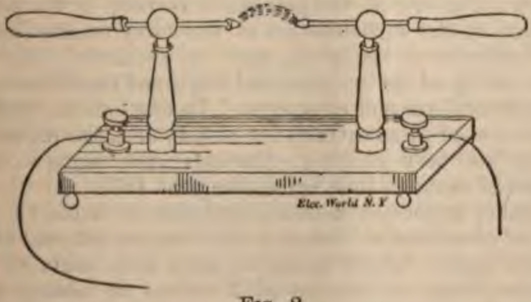


FIG. 2.

In fact, while in the past such arcs were common, their number is diminishing, as they are being replaced by the more efficient and completely developed arcs called "long arcs," which are so called to distinguish them from the "short arcs." Returning to our separating carbons, we find that as the space or arc is lengthened from the short arc condition we pass a stage of great flickering and unsteadiness and a fluctuating potential between the carbons, and then reach the stage of production of the long or quiet arc. With 10 amperes the separation may now be about $\frac{1}{16}$in. to $\frac{1}{10}$in. or more. Smaller currents require less separation and larger ones an increased separation. At this stage the arc is quiet, with good, pure carbons very steady, and the potential difference remains at about 45 volts, if, of course, the carbon is properly fed to make up for combustion. The perfect arc is really a beautiful phenomenon. While the positive carbon still loses by volatilisation from its tip or crater and by combustion from its sides, the negative gains no deposit; but wastes at a less rate than the other, and by combustion only. The carbon vapour carried off from the positive is consumed by the oxygen of the air before it can deposit on the negative. Hence, the outer zone of flame, which can easily be distinguished from the central zone or arc flux proper, is probably a zone of combustion similar to that existing in ordinary flames.

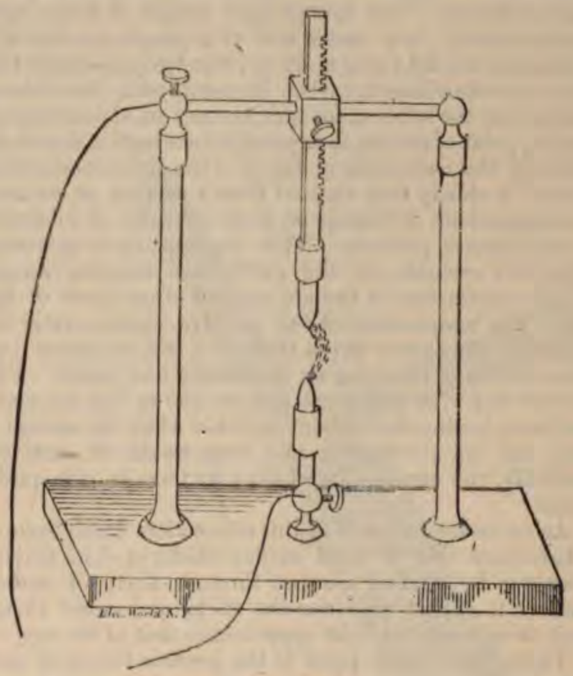


FIG. 3.

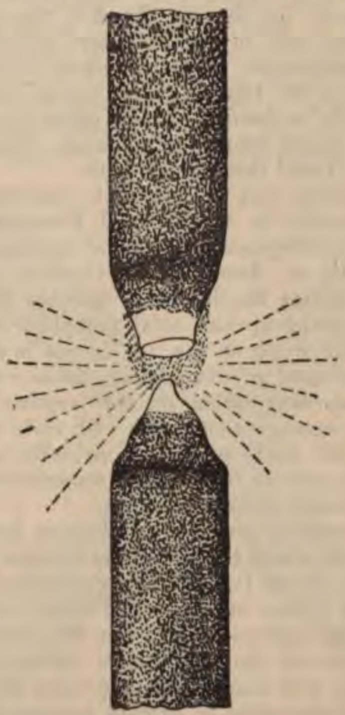


FIG. 4.

of carbon by evaporation from the positive end gives rise to the crater or cup which is so prominent a feature of carbon arcs produced by continuous currents. The size or area of the crater is a rough measure of current strength, but varies with different qualities of carbon. With very long arcs the crater or hollowed end disappears and the ends become rounded. A well-formed crater with the arc or flame confined thereto means usually a steady light, since the chief source of light in an electric arc is from the positive crater, which shines like a diminutive sun and represents the hottest part of the arc. The vapour light proper or flame light is comparatively very feeble and of a purple quality in air. Hence, the arc light is as truly an incandescent source of light as is the incandescent carbon filament, with the difference that to run the latter at the temperature of vapourisation or boiling point of carbon, so to speak, means instant destruction, while by the necessities of the case the light obtained from the arc is chiefly that emitted from a surface of carbon at its temperature of boiling, or, more correctly, of sublimation at atmospheric pressure. This temperature is exceedingly high, and accounts for the well-known superior economy in light production of the arc over all other kinds of lighting. The temperature of the positive carbon crater is so high that the carbon exists there in a soft or plastic condition capable of receiving an impression like putty. I have proved this with very large arcs of 150 to 200 amperes by suddenly forcing the carbons together when the current had been cut off, and finding that they would fit each other perfectly, the negative impressing its form on the positive crater.

As an interesting fact in this connection, I may state that I have been able to bend carbon sticks of $\frac{3}{16}$in. to $\frac{1}{4}$in. in diameter by passing current through them of sufficient amount to almost vapourise the sticks and cause them to emit an intensity of light approaching that of the arc.

These facts would point to the possible fusion of carbon into liquid carbon at arc temperature under a high pressure of inert gas. No one has as yet seen carbon in this liquid condition, and the electric arc alone has made us acquainted with carbon vapour. One cannot fail to be impressed with the fact that the conveyance of carbon in the arc has a striking resemblance to a plating process where metal is taken up by the bath from the positive plate and deposited on the negative. In the arc the hot vapour stream of flame takes the part of the bath and probably acts by molecular interchanges of carbon atoms in molecules of carbon to cause the transfer which occurs, just as in the plating-bath the molecules of the plating compound are polarised and allow atomic interchange, which results in conveyance of metal through the bath.

Another curious fact in relation to the arc is the distribution of potential in it. Dr. A. J. Fleming has recently shown that the difference of potential between the positive carbon and the arc flame is about 40 volts; and the few volts which express the difference between the flame and the negative make up the total potential—say, 45 volts. Hence the real work of the arc is not in the flame, the energy is not used in overcoming flame resistance, but chiefly in vapourising carbon in the positive crater. It is certainly not strange that, with 40 volts and, say, 10 amperes or 400 watts expended virtually at the crater surface of the positive carbon, the temperature and luminous effects should there be so great.

The distribution of potential in the arc just noted was also brought out about the year 1884 in some testimony in an interference in our Patent Office concerning an arc lamp cut-out which I had invented and which took advantage of the potential differences between the carbons and the arc flame to cut out the lamp when the arc was too long. It is, of course, well known that the value of an arc light for general illumination is greatly enhanced by the fact of the distribution of light being mainly in a downward direction in continuous-current arcs. This, of course, follows from the fact of the positive carbon crater being above, such crater being the part from which most of the light comes.

This matter has been quite thoroughly investigated, and many diagrams of distribution are to be found in the literature of the subject as published from time to time. They show that with the long arc the maximum intensity of light is from 40deg. to 60deg. downward from the horizontal, and that the horizontal intensity is generally much less than one-half as great, while of course the intensity diminishes above the horizonal direction and ultimately becomes zero before reaching the upward vertical direction. In like manner the approach to the downward vertical from the direction of maximum intensity is attended with similar rapid diminution.

The spherical candle-power of arc lights would therefore be only a fraction of the rated candle-power which is generally taken at the maximum light obtainable in the best direction from the particular arc or kind of arc in question.

For this reason the term 2,000 c.p. arc has little significance as indicating the illuminating power of an arc. It is a conversion only, and a poor one at that. It is now generally taken to mean an arc with 10 amperes and not less than 45 volts potential difference between the carbons, or a 450-watt arc. The quality of the carbons will determine whether the 450 watts will be expended in obtaining the most light or not, or whether that light will have a maximum intensity at one angle or another within certain limits.

When arcs are operated on by alternating currents, the effects mentioned are only partially exhibited, and the phenomena of the crater are, of course, masked or obliterated on account of reversal of function of the carbons. Unless the alternations are rapid such arcs are liable to extinction at the zero points of current, particularly when run in a draught of air. A strong draught of air or a displacing magnetic field may, of course, so disturb an arc as to cause its extinguishment.

In the early years of the growth of arc lighting as a means of illumination the effects obtained were not of the best. Unsteadiness was the rule, and it required much persistent effort to discover the causes and find the remedy.

The prominent defects were, and we may add are still, hissing, sputtering, flaming, and general unsteadiness. Hissing or frying comes, of course, with too short an arc and may be connected with too vigorous vapourisation. They may also be due in some cases to a carbon of too coarse a grain. Sputtering may arise from impurities in the carbons and flaming from too long arcs, from impure carbons, or from carbons insufficiently baked and containing unexpelled gases. Running an arc at a length between the long-arc condition and the short-arc condition may cause great unsteadiness of light. There is, in fact, a critical point in the length below which there is a considerable fall of luminosity and a drop of nearly one-third of potential. As an arc lengthens by combustion of its carbons beginning below this critical point, great unsteadiness will be manifested on arriving at the critical state; and a little longer arc brings about a sudden and very marked increase of potential, of illumination, and of steadiness.

Any observer may easily detect these conditions without special effort. The earlier carbons used with arc lamps in the United States were both badly conducting, impure, and badly made. Copper coating was a necessity. French or Carré carbons were much better, but were too costly to import. The use of the petroleum carbon, or the carbon obtained by the carbonisation of the tarry residue left in the distillation of crude oil, made a wonderful difference in the purity of the carbons, and improved machinery gave accuracy of form and cheapness. To one familiar with the former cost of same carbons for battery arcs, the reductions in cost are very striking: Carbons $\frac{3}{16}$in. square cost a number of cents an inch before the year 1878.

Another important matter in relation to carbons is that the size of section or diameter must be proportioned to the current used. Where attempts have been made to prolong the hours of burning of a carbon by enlarging its diameter beyond certain limits it has resulted in injury to the character and distribution of the light. Large diameters of carbon may burn too blunt to let the light out between them.

Likewise, where attempts have been made to prolong the hours of use by employing a harder or denser carbon than before, it has frequently been found that a sacrifice of light has been incurred, rendering the results much less satisfactory.

One of the chief obstacles to the employment of quite small arcs with currents of three or four amperes is the difficulty of obtaining suitably uniform carbons.

Arcs of even as low as two amperes at 45 volts are easily produced, and such small arcs might even have commercial utility if the difficulties in relation to carbons were removed. An arc consuming 90 to 100 watts means, of course, about seven or eight to the electrical horse-power.

On the other hand, very large or heavy current arcs are difficult to control. They are apt to be unstable at times, and when they get to hissing, or, rather, roaring, it is difficult to restore quietness and steady action. The introduction of cored carbons for the positive has, however, done much to remedy the difficulty, and, indeed, to render it possible to obtain very uniform results from arcs in general wherever such results are indispensable. The introduction of the central soft core into the carbon seems to locate the arc centrally, hold it from fluttering or shifting its position on the end of the positive; in other words, the core fixes the position of the crater, and so benefits the light.

It follows, from the fact that the voltage required to sustain an arc with large or small current ranges about 45 to 50 volts, that the larger the current passing in an arc the less its electrical resistance. Hence, well-developed arcs with 4 amperes will have about 11 ohms; with 10 amperes 4·5 ohms resistance, and with 100 amperes ·45 ohm. This fall of resistance with increasing current is easily explained by the broadening or thickening of the arc stream and the widening of the crater on the positive carbon. This widening of the crater also gives increased illuminating power without increase of temperature. It is probable that the actual crater temperature is as great in the small arcs as in the large ones; in fact, this is implied by the quality of the light remaining the same. Nevertheless, the larger the arc the greater the economy or the greater the light-giving power per unit of energy. This would naturally be expected, as the concentration of heat and lessened chances for escape of heat by convection and conduction would conduce to that result.

The fall of resistance with increase of current has an important bearing on the construction of dynamos for arc lighting and the running of lamps on constant-potential or incandescent circuits, and will be referred to later on. Attempts have been made at various times to save carbons in arcs by excluding the oxygen of the air, which is the cause of their waste or consumption by burning. The gain has not apparently compensated for the disadvantages incurred, particularly as the total exclusion of oxygen means that the carbons become blunt. They would be prevented from pointing themselves or acquiring tapered ends by burning, a condition essential to good working and distribution of light. Even when the arc is formed in a vacuum the carbons, though not burned, are slowly consumed and carbon deposited as a soot on the sides of the vacuum-chamber, an effect consequent upon the vapourised carbon in the arc being carried off and condensed again as soon as the vapour escapes the heat of the arc stream.

In fact, I have found it possible to coat objects on the inside of a bulb with silver or other metals volatilised suddenly by arcs in vacuo, and have obtained in some cases coherent brilliant deposits. The metal is raised in vapour as a metallic arc and distills and condenses on the surfaces near at hand.

Before passing to the consideration of the running of arc lamps in series, or in multiple, and the conditions to be fulfilled in each case, we may state that although in ordinary cases an arc is formed by a single pair of electrodes or carbons, and by a single-circuit current, compound arcs, or arcs produced by combinations of two or more currents with three or more electrodes, are possible. I am not aware that any others than myself have experimented in this direction. I have, however, produced lights with two positives and one negative, with one positive carbon, or crater, and two, three or more negatives and with two positives and two negatives. I have caused arcs to cross each other, as when four carbons are used, pointing toward a centre, the two pairs opposite being respectively connected with different circuits. In this way direct arcs have been, as it were, mixed with alternating arcs and a curious compound effect produced by crossing two arcs made with two alternating currents, the waves of which are displaced in phase. Without going fully into these experiments, I will present figures showing two good examples. Fig. 5 is formed by two currents sent into a positive, and dividing after passing the crater into two streams going to the two negatives. In this case the positive crater is fully exposed horizontally, and gives a most intense light in a direction forward. Such an arc is well adapted for projection by mirrors or lenses.

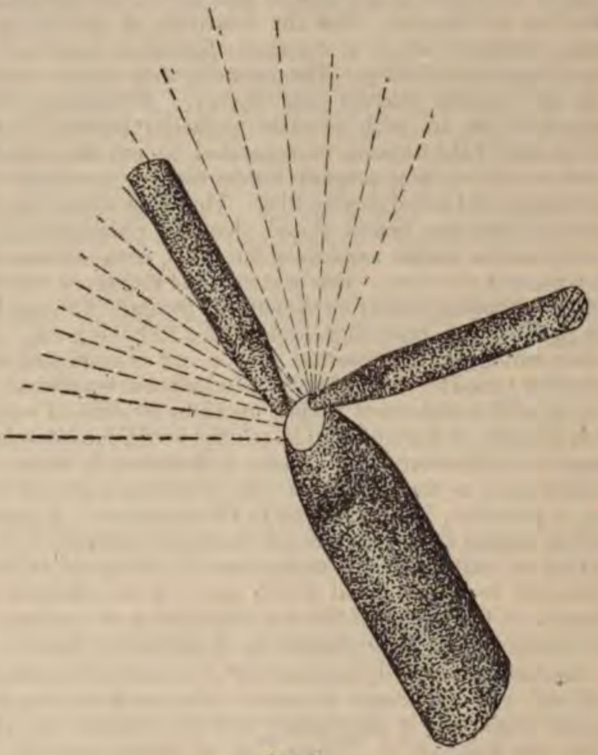


FIG. 5.

Fig. 6 shows the arc formed by crossing two alternating currents out of phase. In this case there is at successive times an exchange of current between all four carbons in varying directions so that the arc flame becomes, as it were, a ball or disc of very hot flame supported by the four carbons. These experiments have not been fully described as yet, owing to the lack of time; but they show very well that even when we have fully studied the single, simple arc we will not then have exhausted the subject, as these compound arcs may be varied in character to a great extent and present new effects.

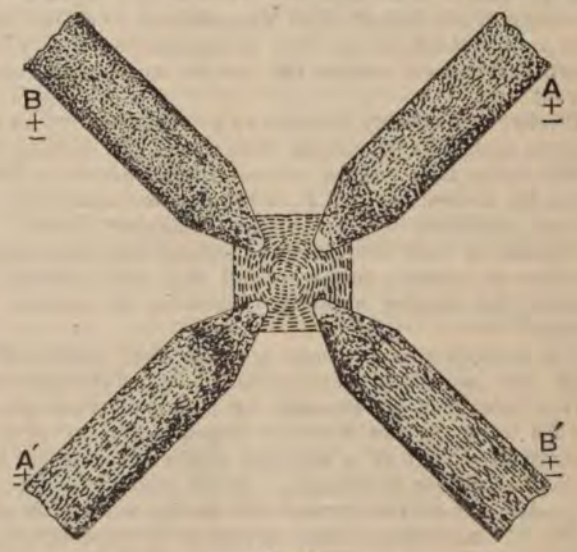


FIG. 6.

In regard to that portion of our subject which concerns the use of the electric arc for lighting, it is true that there is a wide field before us. I cannot hope to do more in this paper than to outline, in addition to the considerations already alluded to, some of the other prominent features of this subject. It is well known that by far the larger proportion of electric arc lights in operation is run on circuits of constant current, the lights being in series.

If arc lamps be connected in parallel, as on low-potential incandescent mains, special devices are required to keep the current supplied to each lamp at the right amount.

It may appear at first to one who has not had occasion to closely study these matters that, given a constant-potential circuit of 50 volts, arc lamps requiring 50 volts could be connected in multiple or parallel without difficulty. The fact is, however, that the condition of electric arcs being supplied with a constant potential involves a theoretical impossibility. Theoretically, such an arc would take an infinite current and energy. Practically, the current in an arc with constant potential becomes very heavy, and if the carbons be separated to cut the current down as by a lamp-magnet mechanism, a condition of fluctuation and instability results. This is a direct consequence of the fact before stated, that the resistance of an arc is not like a wire resistance, but falls with increase of current, and *vice versâ*. For stability the resistance should not be dependent wholly on the current passing. To remedy the instability a resistance known as a "choking coil," or "sluggishing coil," is inserted in the arc branch, and the potential raised to 65 or 70 volts. Under these conditions—that is, with a resistance taking up 15 to 20 volts in series with the arc—it may be run in multiple with incandescent lamps or with other arcs. There is, however, a waste of energy equal to the product of the current strength of the loss of potential, 15 or 20 volts, in the resistance. A great deal of useless experimenting has been and probably is yet carried on with the vain endeavour of getting rid of the resistance or choking coil in this case, but the difficulty is inherent in the nature of the arc, the relation of resistance to current giving rise to instability of current in the arc.

Similarly, not all dynamos, even if of sufficient potential, will run arc lamps in series. Arc machines require special properties, or the current will be unstable and the lights will fluctuate, or "surge," as we sometimes call it, possibly to an extent amounting to extinctions and relightings occurring at short periods apart. This action, like the other, is dependent on the relation of current and resistance as inherent in electric arcs, and the series of lights would in each case require dead resistance up to a certain amount in circuit to render the current stable. Then, whether a series be operated or a single arc be operated, either a dead resistance must exist in circuit or the current-supplying apparatus must have special properties. The arcs produced from batteries were stable because the resistance of the battery itself was sufficient to ensure this. Arcs are not stable as fed from accumulators of very low internal resistance unless the arc is one of enormous current.

Briefly, the property required to be possessed by an arc dynamo is that as its current rises above the normal, the E.M.F. must fall; as the current diminishes to a little below the normal the E.M.F. of the dynamo must rise. It is not sufficient to secure this changing E.M.F. by regulators, as they are generally behind time for causing stability of current, however well they may operate to regulate for varying numbers of arcs in the series to be supplied.

The properties of dynamos are sometimes expressed by what are called "characteristics" or "characteristic curves," obtained, for example, by laying off vertically or on the ordinates the E.M.F.'s corresponding to varying currents given out by a machine, which currents are laid off horizontally or as abscissæ. In arc machines the curve so produced is convex upward and droops at its outer end, *b*, Fig. 7. Assuming normal current at 10 amperes, and an E.M.F. of 500 volts at 11 amperes, the E.M.F. may have fallen to 420 volts, and at nine amperes risen to 530. We would then be working on the "droop" *a* to *b* of the curve when at 10 amperes, and such a machine is stable as to current for running arc lamps. There appears to be required not merely a droop in the curve for securing stability, but more than a certain amount of rate of droop or dip. If the line could be made to droop or dip vertically after passing the normal current the machine would regulate without a regulator, or be a constant-current automatic machine.

In what respect, then, do arc dynamos differ from others to produce this relation of droop in the characteristic curve? Without doubt the effect is mostly due to the reactionary effects of the armature on the field, which effects in arc machines are made greater than in others; and the field magnets meanwhile are frequently saturated magnets, so called, and not greatly sensitive to the current in their coils. The armature of an arc machine is, indeed, so powerful an electromagnet that it is able to control the magnetism of a portion of the field in which it turns. A sort of balance of magnetic forces is established at certain portions of the field, which on an increase of current in the armature produces polarity opposing the field polarity at the portions mentioned, such as will cut off some of the lines of magnetism from entering the armature core and so lower its E.M.F.; while a lessened current in the armature will weaken its polar portions, and an increased number of lines will enter the armature core from the field and so increase the E.M.F. at the brushes of the commutator. In Fig. 8 the portions at K K are those at which the balance or conflict of opposing poles of armature and field magnet exists—namely, at those portions near the diameter of commutator or position of the brushes on the commutator.

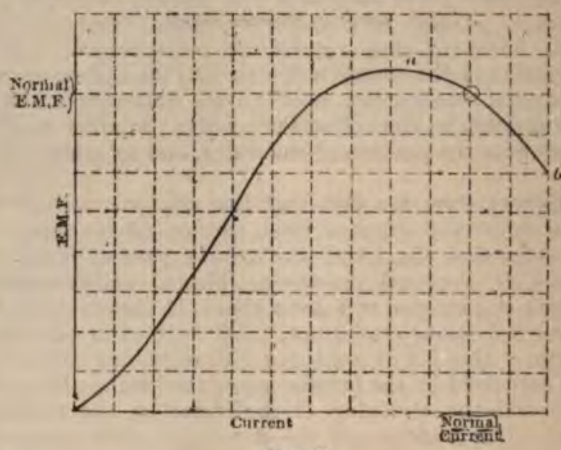


FIG. 7.

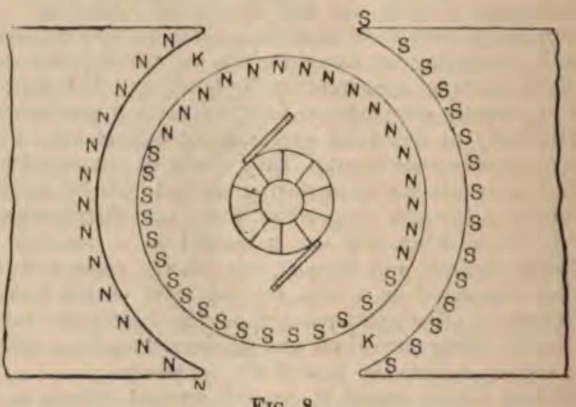


FIG. 8.

Could the droop or fall in the characteristic curve be made a vertical, as stated before, then we should have a self-regulating machine not needing a regulator to preserve a constant current under all loads. This condition is more easily arrived at in alternating machines, one of the first, if not the very first, example of which is founded in the Chertemps-Danden machine which was tested by Robert Sabine, as described in Dredge's "Electric Illumination," Vol. 2, 1885. This machine had the remarkable property of permitting 10 arc lamps to be cut out or put into its circuit in series in any way without causing a variation in current strength of more than 10 per cent. The interactions occurring between the armature and field accounted for this regulating property. In these cases the armature currents react upon the field with a force producing at times a balancing of magnetism between the two. The distortive power of the armature upon the field is made very great, which amounts to the same thing.

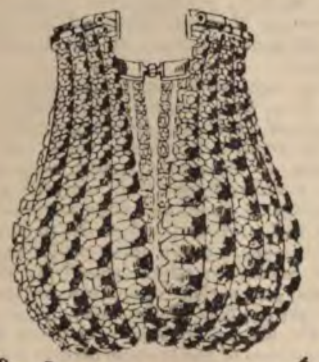
In the recent alternating machine for constant current brought out by Mr. Wm. Stanley we have an excellent example of the application of similar principles of construction, together with the difference that the arc lights which were fed direct in series from the Chertemps-Danden machine are run from the transformers with the primary coils in the Stanley apparatus.

The relation of current to constancy is, however, in continuous-current dynamos for arc lighting generally effected by regulators, as they are called, which so alter the dynamo on a slight increase or decrease of current as to raise or lower its E.M.F. according to the resistance in circuit or speed.

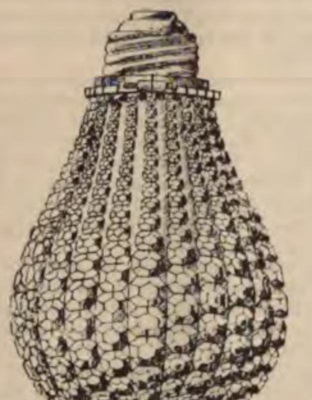
(To be continued.)

DIFFUSION OF LIGHT.

In our notice of the St. Pancras exhibition in our last number we referred to the "Bead Ray-Diffuser," introduced by Messrs. Rashleigh, Phipps, and Dawson. The illustrations given herewith explain themselves, and show how easily the diffuser can be attached to lamps. This is not the first attempt in this direction, and no doubt such apparatus is appreciated where the total amount of light is in excess of the needs, and better diffusion gives greater equality of light over the space lighted.



SKETCH SHOWING SIMPLICITY OF ATTACHMENT



WITH ELECTRIC LAMP RAY DIFFUSER ATTACHED

Electricity and Light.—It is not generally known, says the *Globe*, that some of Dr. Hertz's discoveries were anticipated by theoretic reasoning. In the "Physics of the Ether," by S. Tolver Preston, a notable book published by Spon some years ago, there will be found in the appendix to the volume a prediction of the fact now recognised that static electricity—that is to say, a stable charge as distinguished from a current—is a form of "resonance" of the ether in the charged body; and also some other pregnant suggestions, which are the more remarkable in that the author did not arrive at them by mathematics, but by sheer thought.

ELECTRICITY IN RELATION TO THE HUMAN BODY, ITS DANGERS AND ITS USES.*

BY H. NEWMAN LAWRENCE, M.I.E.E., AND ARTHUR HARRIES, M.D., A.I.E.E.

The subject we have chosen for this paper is one of much interest at the present time. It is intimately connected with the practical utilisation of one of the most valuable developments of modern science, and it also concerns each of us individually.

The connection between electricity and the human body might at first sight seem rather remote, and any attempt to show a close relationship would, a few years ago, have been thought unnecessary and unprofitable.

Now, however, that electric light is in our houses, electric power in our workshops and in our streets, electric telegraphs and electric telephones in our offices, and a considerable section of the public is making more or less use daily of these appliances, it is but natural to turn attention to a consideration of the influence this powerful, yet mysterious, agent has upon the human body.

The full consideration of such a subject would be far more than could be possibly dealt with in this paper, though records of facts connected therewith are few and far between. Our subject possesses little or nothing in the nature of a history, so we hope we may be excused if we deal with the matter mainly in the light of our own experiments and observations.

It is manifest that any consideration of the relation between electricity and the human body must divide itself into two parts: the one, possible dangers to the body, and the other, possible advantages.

We deal with the dangers first: First among the dangers is that from lightning; but this is one which we need hardly enlarge upon here. That lightning is distinctly dangerous, and often fatally so to the human body, is a well recognised fact, and one which is, for the most part, sufficiently guarded against. The physiological problems connected with lightning stroke are many and interesting, but beyond our present scope.

We have rather to deal with dangers arising from accidental contact with conductors which are used to convey electric currents to and from the various lamps, machines, or apparatus they are intended to actuate.

Danger from contact with telegraph, telephone, and electric bell conductors is infinitesimal; for the currents they carry ordinarily are so small that the worst that could happen on making contact would be a slight shock to the nervous system. The smallness of the currents carried would prevent any real electrical danger. Still, it sometimes happens that such conductors receive, through accident to other wires, currents many times greater than they ordinarily carry. Under these circumstances, contact with them becomes distinctly dangerous. While, therefore, we cannot speak of serious consequences likely to result ordinarily from contact with telegraph, telephone, and bell wires, we think they are best left alone by others than those whose special duty it is to look after them.

Conductors of light and power circuits do, however, convey currents which possess great possibilities of danger to the human body, and therefore should be so placed and so insulated as to render it impossible for members of the general public to come in contact with them.

That electric engineers (in England, at any rate) have done, and will do all that is possible to safeguard the public we gladly believe and acknowledge. With proper care on the part of the engineer, and with a minimum of caution on the part of the public, accidental contact by the human body with conductors carrying dangerous currents becomes almost an impossibility; but it does not by any means follow that information as to the consequences to the body of any such accidental contact should not be made known. To be forewarned is to be forearmed.

The results of contact with currents passing at a fixed rate of E.M.F. (as is generally the case in light and power circuits) depend upon resistance, sensation, and local effect. Upon the resistance offered by the body depends the quantity of current passed: sensation and local effect are produced upon the body by such current as it really receives.

Resistance, in its turn, depends upon the condition of the skin at the sites of contact, and upon the extent of the contact area. These points are all-important in deciding the seriousness or otherwise of accidental contact.

We have noted with regret that there is a tendency among electrical engineers to draw unfair inferences from the slight results which have sometimes followed accidental contact. They argue that, because A received no harm from an accident on a particular circuit, therefore no harm can come to B and C, or anyone else, on the same or some similar circuit, quite forgetting that A's hands may have been exceptionally dry, or that the area of his skin in contact may have been very small.

We have made experiments on both these questions, and find as follows:

CONDITION OF SKIN TABLE.—ELECTRODES OF 45 SQUARE CENTIMETRES HELD IN EACH HAND; DYNAMO CURRENTS AT FROM 110 TO 115 VOLTS.

	To continuous-current resistance.	To alternating-current resistance.
Dry	6,185 ohms	4,008 ohms.
Moist	2,450 ,,	1,622 ,,
Wet	1,510 ,,	1,360 ,,

From this it appears that, with continuous-current resistance with the skin moist at point of contact, is about one-third the average of that found when the skin is dry. With wet skin, resistance is further reduced to one-fourth. With alternating current the proportionate decrease of resistance between the conditions of dry, moist, and wet skin is slightly less, but is still well marked.

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* Paper read before the Society of Arts, Wednesday, March 11.

These results were obtained, as before mentioned, with dynamo currents at about 100 volts; and it is interesting to note that nearly the same proportion appeared in the "Comparative Resistance Table," obtained with battery-and-coil currents, which we had the honour of putting before the Institution of Electrical Engineers in a paper in March, 1890, though the actual values there given were much higher with continuous currents.

Some surface-area tests were briefly referred to in our paper read before the British Association in September last on "Alternating *v.* Continuous Currents in Relation to the Human Body (Dynamo Currents)." We have now embodied therewith other observations taken since, and find that other conditions being the same, the current passed with a given E.M.F. is as nearly as possible in direct proportion to the surface area in contact.

These results show at a glance how very large is the influence which these factors of skin condition and contact area have.

By them we find that while it is possible for A to receive only about 4 ma. from a circuit carrying a current of 100 volts if his skin be dry, and the contact area be 10 square centimetres, it is equally possible for B to receive 800 ma. from the same circuit if his skin be moist and 500 square centimetres of it be in contact. In other words, the possibilities for harm are dependent upon these factors to such an extent, that when both are favourable to the subject, contact with wires carrying current in the highest degree dangerous may produce results in no sense serious on the other hand; when both are unfavourable, the subject may receive serious if not fatal injury, from a circuit which might be safely handled under conditions more favourable to himself.

We now come to the consideration of what happens to the body, when the resistance has been sufficiently overcome to allow a perceptible current to pass through. The results may be classed under two heads—viz., sensation and local effect.

Sensation.—We have made many experiments to determine how the sensations of individuals are affected by currents of such strength as could be borne. The results of these have already been published in detail in the papers above referred to, so we will here only summarise them.

We find with dynamo-generated currents, when bare metal electrodes, having a surface area of 45 square centimetres each, are grasped in the hands so that the current passes through the arms and chest, that with continuous current at 104 volts, an average current of 0·0183 ampere produced what we have called discomfort point, while with alternating current at about the same voltage (and a frequency of 23 per second) 0·007 ampere was sufficient to produce comparable discomfort. Further, that with the alternating current 0·0079 ampere produced muscular fixation, while with the continuous current in no case was muscular fixation, or any sensation approaching thereto, reached.

Local Effect.—The action of currents upon the parts actually brought into contact with conductors has scarcely received sufficient attention, nor have we been able to find any detailed description of the effects observed.

It is proposed in the present paper only to deal with the phenomena resulting from the application of small currents, for experiments with large currents are not easy, nor are willing subjects available, not to mention legal and other objections. It is, however, permissible to conclude that in proportion to the power of the current will the effect described be liable to exaggeration.

A. With continuous currents we observe: 1. Electrolysis at the parts in contact, accompanied by a gradually increasing sensation of heat, with the additional sensation of cutting, if the edge of an electrode be grasped or touched. This slowly increases until, when the current be sufficiently large, pain becomes unbearable. If current be suddenly broken, the heat sensation continues to increase for a short period (one or two seconds) then gradually diminishes. 2. Shock to the muscles in the neighbourhood is felt with sudden make or break. This effect usually persists for a considerable time. An unvarying continuous current does not produce contraction of muscle. 3. The parts become reddened, more so at the negative than the positive pole. This is probably due to two factors: (*a*) stimulation of arterial stream near both conductors; and (*b*) paralysis of vasco-motor-nerves at the negative electrode.

B. With intermittent and alternating currents: 1. Repeated shock, with more or less tonic contraction of neighbouring muscles, which is practically persistent during the time of contact. Closure of circuit is marked by painful jerk, felt not so much in neighbouring muscles as in those some short distance away. Thus, when the hands grasp conductors with an alternating current, the jerk is first felt in the forearm muscles, then in those in the upper arm, and the latter is accompanied by pain, which is occasionally long persistent after the circuit is broken (one or more days). 2. Reddening of the parts. In the case of the interrupted or alternating currents, this phenomenon is much the same at positive and negative poles, and is due probably to the same factors as in the case of the continuous current.

Light and power circuits carry currents many times stronger than any used or named in the above experiments; and we may fairly conclude that the result of contact therewith would be severe shock to the nervous system, and strong burning sensation at the points of contact with either form of current. With alternating current there would be muscular fixation, in addition, such muscular fixation rendering the subject quite unable to release himself, and subjecting him to the full effect of the whole current passing.

Where the conditions of contact (as set forth above) are such that the body receives a large portion of the current carried, the results are necessarily very serious to the subject, and may easily prove fatal, either from the violence of the initial shock and consequent fright, or from the continual passage of sufficient electricity to produce death by direct electrical action upon vital parts.

With regard to the relative dangers of the two forms of current (alternating and continuous), what we have above stated clearly indicates that the dangers resulting from contact with the conductors of an alternating-current circuit are far greater than those resulting from similar contact with a continuous-current circuit, even if the E.M.F. of the latter be double that of the former. This part of our subject is dealt with more fully in the papers above referred to.[*]

THE USES OF ELECTRICITY TO THE HUMAN BODY.

The health of the body seems to be intimately connected with, and perhaps to a large extent dependent upon, electricity, or the immediate results of electrical action both internal and external. That electricity ordinarily exists in the air we breathe has been shown by many well-known experimentalists from Lemonnier, in 1752, downwards, and we have it on the authority of Sprague that the average electrical condition of the atmosphere has an important bearing upon the climatic qualities of any place, though he adds "as yet very little is known on the subject."

Again, ozone is a most important constituent in a healthy atmosphere, and it is probable that electrical action is one of the chief factors in its production. Physiologists have long taught us that electricity is generated in our bodies during each functional process of whatever nature. It has been shown to be present during the action of the heart by Dr. Augustus Waller in his beautiful experiments before the Medical School of St. Mary's Hospital in October, 1888, and more recently at the International Medical Congress at Berlin.

We are ourselves engaged upon a long series of experiments, which, so far as they have gone, clearly indicate that small but measurable currents of electricity are being continuously generated in the body. We further find that these currents differ in potential according to the parts tested, and we have reason to believe that such difference of electric potential is produced at the centres of function; thus in muscle, brain, gland structures, lungs, and various parts of the digestive system there is a separate, continuous, though apparently irregular, generation of current. The extent to which this body electricity may be dependent for its generation upon the various physiologico-chemical actions taking place in the body, is a question for the future. Meanwhile, we are content to believe that atmospheric electricity in the process of the transformation and re-transformation of oxygen into ozone and ozone into oxygen, and in other ways passes through a cycle of transmutations, starting as atmospherical electricity, and finishing as the body currents mentioned. We are thus brought face to face with the fact that electricity forms a most important factor in the processes and functions which together constitute life; but there is no evidence in favour, or reasonable probability of proof, of the vaunted and oft-advertised statement that "electricity is life."

A confirmation of our conclusions is found in the experiments of Dr. B. W. Richardson upon the effect of administering frequently used oxygen to animals. He found that oxygen alone will not continuously support life—in presence of nitrogen, of course—unless it be frequently revivified by the passage of electricity through it. The same action of electricity and its revivifying power upon the atmosphere is found after a thunderstorm, when, as is well known, ozone is largely present owing to the electric disturbance accompanying the storm.

The artificial electrical generation of ozone for restorative purposes may also be considered as one of the uses of electricity to the body. It is one, moreover, which may probably prove of considerable importance in large cities, where the atmosphere is vitiated by the exhalations of a large and crowded population. We have made certain investigations into this subject, and carried out some interesting experiments with persons placed in an ozonised cabinet (invented and patented by Mr. Lawrence), wherein the air was charged with ozone by electrical action. The results seem promising; but the number and extent of the observations necessary, prevent the rapid completion of such research, and we must postpone more definite conclusions for the present.

(*To be continued.*)

UNDERGROUND CABLES.[†]

BY STUART A. RUSSELL.

(*Concluded from page 298.*)

The London Electric Supply Company, working at a pressure of 10,000 volts, between Deptford and London, use the Ferranti main, the methods of making and jointing which have already been described. From Deptford to London Bridge, the route followed is mostly along the railway, and here the mains are fixed on the outside of the railway boundary wall. Elsewhere they are laid in the ground, either direct or in a trough filled in with compound. From the sub-stations in various parts of London to the consumers' premises, a pressure of 2,400 volts is employed, and for this two or three kinds of cable have been used. For some years, mains consisting of vulcanised rubber cables in iron pipes have been in use, in addition to the overhead cables, by means of which the greater part of the distribution from their old station at the Grosvenor Gallery was effected. I understand, now, that it is proposed to use concentric cables throughout the whole system, and that these cables will therefore be made concentric. In addition to this, during the last year Siemens concentric armoured cable has been laid in various districts, and at the present time some Fowler-Waring concentric cable is being laid.

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[*] This paralysis of circular muscular fibre is an important factor, for it is one of those made use of in such electro-surgical operations as dilatation of stricture, electrolysis of hair, etc.

[†] Lecture delivered before the Woodhouse and Rawson employés' class, March 6, 1891.

Before concluding, I feel that I must say a few words on the subject of the testing of cables, more especially as this is a point which has, I think, been rather too much overlooked. Notwithstanding the fact that the cost of the underground system of mains is a most important item in any central station undertaking, we still find that a great deal more attention is paid to the subject of testing the machinery, etc., than is paid to that of testing the cables, and that very few people seem to trouble themselves to see that cables are rigorously tested before delivery. I consider that the testing of the cable before delivery under definite specified conditions is most important. For instance, for all cables to be used with high pressure, I would suggest that a test be taken with 500 or 600 volts, the cable being immersed in water, and that then the cable should be subjected to a pressure at least as great as that at which it is to be worked for a certain number of hours, after which the test with 500 or 600 volts should be repeated to see if there is any falling off of insulation. Again, when cable is being laid, each section should be tested before any joints are made, and the test repeated as each fresh joint is included in the circuit. By this means it is possible to follow the behaviour of the cable right through, and to detect at once if any injury has been done to the cable in laying, or if a faulty joint has been made, and to have the same put right; whereas, if no tests are made, or they are not made until the system of cables is complete and a fault exists, it is often a difficult matter to localise it.

When mains are laid and in use, it is important that a continuous test should be kept up whilst the current is on, so that any change in the insulation may be noted at once. Various methods of doing this are in use according to the system of working—*e.g.*, on a low-pressure system each conductor may in turn be connected to earth through a lamp of small candle-power, and the leakage judged of by whether the lamp glows or not. This is of course a very rough test and is only applicable when the insulation is low, but it is very convenient for detecting changes in insulation resistance, and has the advantage of great simplicity, so that it can be made by any station attendant. An actual measurement of the insulation resistance may be made if a high-resistance voltmeter is substituted for the lamp mentioned above, and readings are taken, first, of the potential difference between the two conductors, and, secondly, of the potential difference between each conductor and earth. If we call these three readings V, V^1, and V^2 respectively, and the voltmeter resistance, R, then the insulation resistance, R^1, of the positive conductor $= \frac{R\,(V - V^1 - V^2)}{V^2}$ and that of the negative conductor is $R^2 = \frac{R\,(V - V^1 - V^2)}{V^1}$. The highest resistance = 10 times voltmeter resistance. The highest insulation resistance that can be measured in this way is generally about 10 times the voltmeter resistance. It will be seen from these values that the insulation resistances are proportional to the voltmeter reading between earth and the conductors, and if a very high reading is obtained on one and a very low reading in the other conductor, it shows that there is a fault of considerable magnitude on the latter. This is sometimes measured by connecting the first conductor to earth by a low reading ammeter and obtaining the insulation resistance by dividing the volts between the two conductors by the amperes or fraction of an ampere which passes.

Another method is to form a Wheatstone bridge by means of the two leakage resistances, a known fixed resistance, R, and an adjustable resistance, the galvanometer being connected between earth and the junction of the fixed and adjustable resistances. By adjusting until a balance is obtained the ratio between the two insulation resistances is found, say, $\frac{x}{y} = \frac{\rho}{R}$ where ρ is the value of the adjustable resistance. Now connect a known resistance, R_1, between earth and the conductor whose insulation resistance we have called x, and again obtain a balance, this time with ρ_1 ohms in the adjustable resistance, then $x = \frac{R_1}{\rho_1}(\rho - \rho_1)$.

Owing to the difficulty of getting voltmeters or lamps which can be used with high pressure, the methods mentioned above have to be modified before they can be used on circuits working at high pressure. For continuous currents a number of lamps in series, or a voltmeter with a large added resistance may be employed, and for alternating currents a transformer may be used, the primary circuit being connected between a conductor and earth, whilst the secondary circuit is connected to a lamp or to a non-inductive voltmeter. Another method is to substitute for the lamp a vacuum tube placed inside a darkened box, the terminals of the tube being connected respectively to earth, and to the conductor under test. In this method, if the insulation is good, there is a visible glow due to the discharge through the tube, and this glow diminishes in brightness as the insulation resistance becomes less, thus giving an indication of the state of the mains.

Although the methods mentioned above are sufficient to indicate the presence of a fault on the circuit, they cannot tell more about its position than that it is on one particular side. In order to localise a fault by testing, it is always necessary to know the true conductor resistance of each part of the circuit, and this is practically impossible in a network of conductors, when the two sides are connected together by a number of lamps, transformers, or other apparatus. There are special cases in which a fault of local resistance may be localised by testing from the station, but in the majority of cases this is practically impossible, and herein lies one of the great advantages of a system like that used by the Metropolitan Company, and by several companies working low-pressure systems, when the mains are so arranged that they can be easily divided up into a number of separate small sections, each of which may be tested by itself. Again, should there be two distinct faults causing the leakage, then, even in the special cases which allow of one fault being localised, the position indicated by the test would be the position of the resultant fault—that is, a position somewhere intermediate between the two faults, where very likely the insulation of the mains may be very good. There is one method, which has been used by one or two companies, which consists in wheeling along the route of the main a trolley carrying an iron plate on which is wound a coil of wire connected to a telephone, whilst an alternating or pulsating current is sent into the conductor. It is said that when near the fault there is a distinct change in the character of the sound emitted by the telephone, and that faults have been successfully localised by this means. I have never myself had an opportunity of trying this method, but should think that although the proximity of the fault will change the sound, yet owing to the numerous other conditions in and under our streets which might also change the sound of so delicate an instrument as a telephone, there is a very good chance of discovering faults which have no existence, except in the telephonic apparatus itself. Failing this method, and in the present state of our knowledge, or want of knowledge, on this subject, it is probably best to arrange the circuits in such a way that they can be easily subdivided, and that the faulty section, when found, can be pulled out and replaced by another without stopping the supply of current to any, or at the worst to more than one or two customers.

In conclusion, I would wish to draw attention to the fact that in the majority of cases underground mains are as yet in their infancy, and that therefore the practical experience which will be gained during the next five years or so will probably add very largely to our knowledge of the subject, as the advantages or disadvantages of the various methods are emphasised by the test of actual use.

THE BRAY ELECTRIC RAILWAY.

According to the *Freeman's Journal*, the Commissioners of Bray township met last week as a special grand jury, pursuant to the provisions of the Tramways and Public Companies (Ireland) Act, 1883, and incorporated Acts, for the purpose of enquiring whether the provisions of the statutes had been complied with by the promoters of the Bray Electric Tramway, also for the purpose of enquiring into the *primâ facie* merits of the undertaking, and to approve, disapprove, or otherwise act in relation to the scheme as they consider advisable.

Mr. Martin Laughton, C.T.C., presided.

The other Commissioners present were—James Hennessy, J. E. M'Cormick, James Coffey, Matthew O'Byrne, Daniel Tierney, B.A., C.E., Garrett Nolan, Columba Dunne. Mr. George Keogh, J.P., solicitor to the Board, and Mr. P. F. Combers, C.E., township surveyor, were also present.

The requisition and notice convening the meeting was read.

From the surveyor's report it appeared that the promoters of the line were Mr. James Boyle and Mr. Wm. A. Trail, C.E., "Giant's Causeway Electric Railway," and they proposed running entirely within the township and to work the cars by electricity. The line, it was proposed, should commence at the north end of the Esplanade, near Martello-terrace, running thence southwards along the Strand road, and immediately adjacent to the Esplanade fence, passing in front of Lacy's Bray Head Hotel, and terminating at the foot of the mountain. There were practically neither gradients nor curves to be contended with, and the gauge proposed was three feet, grooved rails to be used, the uppermost surface being level with the roadway.

Mr. H. F. Stephens, solicitor, on the part of the promoters, asked if any objections had been lodged against the scheme.

The **Secretary** replied negatively.

Mr. Stephens remarked that, under these circumstances, he might almost take it for granted that there was not any objection of any kind, and that their scheme would be unanimously approved of. He then stated that all the preliminaries required by the Act had been complied with.

The evidence having concluded, the Commissioners held a meeting to consider the proposals which had been submitted.

Mr. Hennessy said that he had not changed his mind since 1887, and would support the project on similar conditions, but not this scheme.

Mr. O'Byrne opposed the scheme on the grounds that the road was narrow enough at present, and that the tramway was not required at the place.

Mr. M'Cormick proposed: "That we disapprove of the Bay Electric Tramway on the following grounds: 1. That it is not required in the township. 2. That we consider it would be dangerous to the traffic of the Esplanade, especially to children and aged people. 3. That the rails laid without paving would be an element of danger to vehicular traffic, and that owing to the narrowness of the Esplanade road in some parts it would be an element of considerable danger."

Mr. Tierney seconded the motion, which was supported by **Mr. Coney** and adopted.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £6,174.

City and South London Railway.—The receipts for the week ending March 21 were £766, against £749 for the week ending March 14.

Western and Brazilian Telegraph Company.—The receipts for last week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £5,103.

Telephone Company of Egypt.—The eighth ordinary annual general meeting was held on Monday, General Alexander Fraser in the chair. He stated that during the past year the business had been kept up to a fair point of prosperity. The benefits from the establishment of the exchanges at Port Said and Assiout would, however, only be felt in this and following years; while the working expenses had necessarily increased on this account. For any large extension of business they must wait for the reviving prosperity of the country. Much of the trade had been transferred from Alexandria to Port Said and Suez. They hoped to conclude negotiations for opening at Suez this year. They had had from time to time negotiations with the Egyptian Government as to the establishment of telephonic communication between Cairo and Alexandria; but the Directors had come to the conclusion that such a line would cost not less than £12,000, and would probably not give even a moderate return to the Company. The Government might perhaps erect the line, allowing the Company to work it in connection with the exchanges at either end. The report was adopted, and a dividend of 6 per cent. on the preference shares was declared.

PROVISIONAL PATENTS, 1891.

MARCH 16.

4641. **Electromagnetic counter and time indicator for indicating the movements of moving bodies.** Josef Goriup, 89, Chancery-lane, London.

4643. **Improvements in and connected with chains, cables, and couplings for electrical mains and other purposes, or for insulating, protecting, carrying, or conveying electrical mains and other elements, and in preliminary preparation or insulation of such mains for being so carried, conveyed, and protected.** Philip Henry Williams, Egham, Surrey.

4669. **Apparatus on the principle of utilising heat as a source of electricity.** Victor Hirbec, 20, High Holborn, London.

4678. **Improvements in terminals for electrical purposes.** James Pitkin, 6, Bream's-buildings, London.

4682. **Improved means for securing safety in electrical supply systems.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

4684. **Improvements in instruments for measuring and adjusting magnetic force.** William Mayes, 1, Queen Victoria-street, London.

4689. **Electric switches.** Charles Ebenezer Challis, 88, Queen Victoria-street, London.

MARCH 17.

4715. **Improvement in a process of and apparatus for electrically reproducing uneven, irregular, or undulating surfaces.** Noah Steiner Amstutz, 52, Chancery-lane, London. (Complete specification.)

4740. **Improvements in and connected with electric signalling for railways.** George Frederick Attree, 1, Quality-court, London.

4751. **Improvements in electrical transportation systems.** Oliver Imray, 28, Southampton-buildings, London. (Schuyler S. Wheeler and Charles S. Bradley, United States.) (Complete specification.)

4757. **Improvements in the electric reduction of aluminium and other metals and in the production of alloys thereof.** Thomas Leopold Willson, 55, Chancery-lane, London.

4758. **Improvements in electric railways.** Alexander Melville Clark, 53, Chancery-lane, London. (The Waddell-Entz Electric Company, United States.) (Complete specification.)

4767. **New or improved wall fittings or plugs for portable electric lamps, also applicable to suspended electric lamps and other electric apparatus.** Paul Mowbray Turquand, 77, Chancery-lane, London.

4781. **A new or improved solution or electrolytic fluid for galvanic batteries.** William John Engledue, 115, Cannon-street, London.

4792. **Electric type-writers.** Edward Jennings Silkman, 24, Southampton-buildings, London. (Complete specification).

4794. **Improvements in signalling and telephonic systems.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

MARCH 18.

4812. **Improvements in the construction of incandescent lamps.** Henry Alexander Millar, 40, Rockbourne-road, Forest Hill.

4831. **Improvements in holders for incandescent lamps.** William McGeoch, Jun., and Andrew Jackson McGeoch, 87, St. Vincent-street, Glasgow.

4838. **Improvements in incandescent electric lamps.** Mark Bailey and John Warner, 21, Finsbury-pavement, London.

4860. **Improvements in apparatus for heating and welding by the electric arc.** Henry Howard, 24, Southampton-buildings, London.

4869. **Improvements relating to primary and secondary electric batteries and to the manufacture of plates or electrodes for use therein.** Henry Harris Lake, 45, Southampton-buildings, London. (Lucien Alfred Wilhelmine Desruelles, France.)

4877. **Improvements relating to plates or electrodes for primary and secondary batteries, and to the production of compounds or agglomerates for the manufacture of such plates or electrodes.** Henry Harris Lake, 45, Southampton-buildings, London. (Ernest August George Street and Lucien Alfred Wilhelmine Desruelles, France.)

4881. **Improvements in electric tramways or railways.** Alexander Melville Clark, 53, Chancery-lane, London. (Sigmund Schuckert and Co., through Wirth and Co., Germany.)

4882. **Improvements in electric indicators.** Frederick James Duck, 88, Hatton-garden, London.

MARCH 19.

4904. **Improvements in or connected with electric alarum clocks or timepieces.** John Harrison Turner, 34, Belleville-road, Bolingbroke-grove, Wandsworth, London.

4949. **Improvements in galvanic batteries.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (Alfred Tardy, France.)

MARCH 20.

4988. **Improvements in type-printing instrument for telegraphic purposes.** Warren Thompson, 24, Grange-park, Thornton Heath, Surrey.

5003. **Improvements in holders or supports for incandescence electric lamps.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (Theodore Mace, Holland.)

5021. **Improvements in electric accumulators.** Henry Harris Lake, 45, Southampton-buildings, London. (Giovanni Gandini, Italy.) (Complete specification.)

5043. **An improved apparatus for regulating the approach of the carbons in arc lamps.** Alfred William Money and Herbert Nash, 23, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1878.

3988** **Electric lighting.** Lane Fox and another. Fourth edition. 6d.

1885.

11032* **Electric meters.** Oulton and Edmondson. Amended. 11d.

1890.

3193. **Electric transformers.** Swinburne. 8d.
3272. **Electric switches.** Fletcher. 6d.
3937. **Electric flash signalling lanterns.** Rawson and Snell. 8d.
4984. **Electric telegraph apparatus.** Robinson. 8d.
5008. **Electro-telephonic apparatus.** Furtado. 6d.
5016. **Electric reversible machines.** Bary. 8d.
5750. **Dynamo-electric machines, etc.** Crompton (Fritsche). 8d.
5938. **Secondary element.** Boettcher. 8d.
6267. **Electrical conductors.** Marx. 8d.
6392. **Safety fuses for electric currents.** Bláthy. 6d.
6475. **Electric safety device.** Lowrie and Hall. 8d.
6495. **Electric telegraphs.** Clark (Schuckert and Co.). 8d.
7335. **Incandescent lighting.** Macaulay-Cruikshank (Reissing and others). 8d.
20510. **Electrically welded metal articles.** Lake (Wood). 8d.
21183. **Electric protective and signal systems.** Mills (Ongley). 2s. 2d.

1891.

965. **Therapeutic magneto-electric machines.** Leigh (Gardiner). 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday.
Anglo-American Brush	—	2¼
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2¼
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4¾
Electric Construction	10	7¼

NOTES.

Erratum.—Guttapercha core, p. 312, line 15, for *quarter* percentage read *greater* percentage.

Harwich.—Tenders for the public lighting of Harwich must be delivered on or before to-morrow, April 4.

Finchley.—The Finchley Local Board is going to consider the question of lighting their district by electricity.

Bank Holiday Traffic.—On Easter Monday the City and South London Electrical Railway carried about twenty-five thousand passengers.

Drawbridges.—The Thomson-Houston Company has proposed to work four of the swing bridges at Chicago by electric motors, and tests are to be made with one bridge.

Blackpool.—The Blackpool Electric Tramway Company have had two new cars constructed for them, and which were brought into operation for the Easter holidays.

Institution Paper.—On Thursday, April 9, at 8 p.m., before the Institution of Electrical Engineers, a paper will be read on "The Design of Multipolar Dynamos," by Mr. W. B. Esson, member.

Indianopolis.—An illustration of the wholesale way in which electric lighting is being adopted in America is shown by the recent issue of tenders at Indianopolis for 800 or 1,000 arc lights of 2,000 c.p.

Storage Traction.—The Oerlikon Company, who, together with M. Hostmann, are running an electric tramway at Heldburghausen, are going, it is stated, to abandon the use of storage cells on this line.

Electric Miners' Lamps.—There will be an exhibition of miners' electric safety lamps at the annual meeting of the Federated Institution of Mining Engineers, to be held in London at the end of May.

German Telegrams.—The new tariff reducing the price of telegrams in Germany came into force on February 1 last, and has resulted in an increase of 7 per cent. on the total number of telegrams during the month.

Society of Arts.—On April 29, Mr. W. M. Robinson will read a paper upon "The Use of Petroleum in Prime Movers"; and on May 6, Mr. J. E. H. Gordon will read a paper on "Recent Development in the Public Distribution of Electricity."

Personal.—Owing to the increase in the business of the Electrical Accessories Company, it has been found necessary to modify the arrangement of the staff, and Mr. C. L. Schwind, son of Mr. Charles Schwind, the chairman of Messrs. Handysides, of Derby, has been appointed manager.

Brussels.—The Brussels authorities have, it appears, nominated M. Wybauw, chief electrical engineer to the State, to draw up a scheme of charges which will be first submitted to well-known electrical engineers, and which will then serve as basis for tenders for a first installation of 20,000 lights.

Telegraph to Orkney and Shetland.—Provost Peace, Kirkwall, has received a letter from Lord Lothian informing him that the Government have agreed to the extension of the telegraph to Westray Island, Orkney, and to two places in Shetland. It is expected that the cable will be laid very shortly.

Gas Dividends Affected.—At Perpignan the gas company have had to declare a dividend of 30f., a decrease of 17f. 50c. compared with last year. At Mentauban the electric company is smaller, and the gas company very active, yet the dividend is decreased by 10f., being 40f. instead of 50f. last year.

Weems Express.—The Weems electric express has been tested by Mr. O. T. Crosby at speeds up to 120 miles with a specially-built car. The track was very defective, and the car several times ran off the rails, once at 115 miles an hour. A new track is now to be built. Great hopes are entertained of a "speedy" practical result.

Ballymena.—The results of the tenders for lighting Ballymena (Ireland) with gas or electricity, from Aug. 16 to May 16, 1892, for the Town Commissioners, were as follows: Gas—Ballymena and Harryville Gas Light Company, Limited (accepted), £336. 3s.; electricity—J. E. H. Gordon and Co., 11, Pall-mall, London, S.W., £365.

Vienna and Berlin Telephone.—During the course of the year arrangements will be made by the Austrian and German authorities for telephonic communication between Zittau and Reichenberg. This is understood to mean, probably within the year, a direct line between Vienna and Berlin, though so far it is intended only for the two places mentioned.

Electric Traction at Marseilles.—The tramway company at Marseilles have decided to adopt the overhead conductor system of electric traction for their new line. This installation of electric traction, the first of its kind in France, for the crowded streets of a town, has been entrusted to Messrs. Sautter, Harlé, et Cie., and to the Oerlikon Works.

Technical Review.—A kind of technical "Review of Reviews" will shortly appear in the *Pantobiblion*, a monthly international review of current technical literature. The purpose of this new monthly, says the *Newsman*, is to help the literary men of any department concerned with the applied sciences generally, and particularly those devoted to any technical studies of any specialty.

Old Students' Association.—On Wednesday, March 25, a most interesting paper on "Coal, Coal Mines, and Coal Mining" was read before the Old Students' Association at Finsbury Technical College by Mr. Albion T. Snell, following which an interesting discussion took place. A paper has been promised for this session by Dr. Silvanus Thompson on "The Recent Advances in Optics."

Hampstead.—The Vestry have appointed a sub-committee to investigate the cost of electric lighting. The consideration of their report was postponed from last week's meeting to a special meeting on April 16th, the report meanwhile to be printed and circulated. The Vestry will also hold a statutory meeting with reference to their applying for a provisional order on May 7th.

Cleckheaton.—At the last meeting of the Cleckheaton Local Board, the clerk was instructed to inform Mr. W. B. Hutchinson, C.E., Liversedge, that the tenders obtained with the view to the lighting of the new town hall by electricity had been got simply for purposes of comparison of the cost with the cost of gas lighting, and that other firms would be at liberty to tender when the proper time came.

Science Studentships.—The Lords of the Committee of Council on Education will be prepared in future to pay three-fourths of the fees at the University of St. Andrews for a limited number of teachers engaged in teaching science classes in connection with the Department of Science and Art. Applications must be made to the secretary, Department of Science and Arts, London, on a form provided for the purpose.

Prof. Tyndall Seriously Ill.—We are sorry to hear that Prof. Tyndall has suffered another relapse. His condition on Tuesday morning was regarded as so serious that Dr. Buzzard was summoned from town to Hindhead House, Haslemere, to hold a consultation with Dr. Whiting. Late on Wednesday evening it was reported that the professor was weaker, and that his condition gave rise to a considerable amount of anxiety.

Societe Internationale des Electriciens.—The executive council of the Société Internationale des Electriciens has passed the decision that the president should be nominated a year in advance, so that he can fulfil his functions. Presidents proposed at the last meeting were: For 1891, M Joubert; 1892, M. Carpentier; general secretary, M. R. V. Picou; secretaries, MM. Hospitalier and Max de Nansouty.

Steamship Lighting.—The new steamer "Julia," built for Senores Sobrines de Herrera, of Havana, by Messrs. David J. Dunlop and Co., Port Glasgow, is fitted throughout with a complete system of electric light by Messrs. Norman and Son, Limited, of Glasgow, by whom a powerful search-light has also been supplied to meet the requirements of the navigation the vessel will trade under in narrow channels or in entering ports.

Dover.—At the last meeting of the Dover Town Council, the town clerk reported that the Local Government Board would only allow the sum of £115 to be borrowed, being the cost of enquiry, and that the cost of the provisional order could not be borrowed. This decision drew forth the opinion of Councillor Pepper that he thought it would have been the other way—that they were bound to get the provisional order even if the expenses were not allowed.

Determination of the Ohm.—In the paper by Prof. Viriamu Jones, of Cardiff, read before the Royal Society last November, and just published, the value of the ohm, determined by special and very exact methods, is given as 106·307 centimetres of mercury of 1 square mm. sectional area, in place of the 106·3 now taken as the legal ohm. He gives this, however, only as a closer approximation to the exact measurement, and hopes to see it yet still more exactly determined.

Electricity at the Docks.—Along the docks, cranes and hoists of all kinds are now worked by hydraulic power. At every new work of this kind, new docks and new warehouses, our electrical engineers should keep a sharp look out to interest the architects, engineers, or Government authorities in the utilisation of electric motors. The scope in this direction is certainly not small, and might be perhaps combined with small electric tramways for transport of goods.

Hartwood Asylum.—Tenders are required in connection with the lunatic asylum now being erected at Hartwood, in the parish of Shotts, Scotland, for the electric lighting, including all dynamos, wiring, and fittings, for the Lanark District Lunacy Board. Persons desirous of tendering are requested to send in their names to the architect, Mr. John L. Murray, I.A., Heavyside, Biggar, N.B., who will instruct the measurers to issue the necessary schedules so soon as they are ready.

Reduction of Telephone Charges.—It is announced that the charges to the public for the use of the Post Office telephone exchanges in various towns throughout the country have been reduced, and that from the beginning of this week they will be as follows: for subscribers within quarter mile of the exchange, £8 a year; half mile of the exchange, £10 a year; three quarters of a mile of the exchange, £12 a year; one mile of the exchange £14 a year. At the same time a reduction has been made in the charges for ordinary private wires.

New Welding Process.—A patent has been recently granted Hermand Nerup and L. M. Schmidt for a new method of electric welding, the process being to form longitudinal joints by a soldering, cementing, or welding operation, by feeding the pieces through suitable pressure or other devices while properly arranged, so as to be pressed together and passing a heated electric current through the material in a longitudinal direction before it reaches the welding devices.

Giovanni Accumulator.—The active material is introduced in the Giovanni accumulator under pressure into the cavities of a copper grid, obtained by casting and presenting a large number of small cells. The process of manufacture is to immerse a series of these plates in a bath of lead salt, and connected to the negative pole of a powerful source of electricity; the spongy lead is precipitated, and then by compression in a hydraulic press is driven into the small cells, at the same time making the whole plate very solid. The formation takes place in the usual manner, and only requires a few hours.

Talking Across the Street.—An amusing illustration of the longest way round being the shortest way home is given in a paragraph that is going the round of the papers, of two telegraph operators who used to dine together, one of the Submarine, working to France, and the other of the International, working to Holland. The first requested connection to Amsterdam and thence to Brussels. This was done, and Brussels was requested to switch on to Calais and Calais to London, at the end of which operation the telegraph clerk who held the line asked his "chum" whether he had found his pipe!

Direction of Dynamo Currents.—The following rhyme will prove serviceable in determining the direction of flow of current in generator coils, *if remembered*:

If we thread a coil with a line of force,
And look through the coil at the Boreal source,
The current induced will flow clockwise.
If the coil should tilt and the thread slip out,
The current will follow an opposite route—
I.e., contrary to clockwise.

The poet requests us to mention, says the editor of the *Electrical Review* (N.Y.), that "Boreal source" is a figure of speech for "north pole" of the magnetic system.

Southampton.—The question of alleged dilatoriness and obstruction in relaying the streets by the Southampton Electric Light Company was brought up at the last meeting of the Town Council. Several members complained, but Mr. Hamilton, secretary to the company, said he had only received one complaint, and wished people would come to the company instead of trying to make capital out of the matter by bringing it before the Council. A resolution, requesting the town clerk to write to the contractors stating that the Corporation insisted on the work being more expeditiously carried out, was, however, proposed and carried.

Steep Electric Tramways.—A novel method of running electric cars on steep hills has been proposed by Mr. Kuhlmann, engineer to the electric tramway company at Seattle, U.S. At one point on this line is a rise of 16 in 100, about 800ft. long. The electric motors used on the cars are not of sufficient power to surmount the hill, and an auxiliary motive power of some kind is necessary. An independent cable plant would be much too expensive. The proposed plan consists in having a small conduit the length of this hill, in which a counter balance car runs down as the electric car runs up and *vice versâ*. Only one car is on the incline at once, otherwise a larger conduit and two weights would be necessary. It is intended to begin the construction of the road as soon as the necessary castings can be made.

Presentation.—We are sorry to note that Mr. A. D. Stevenson, who has for some years acted as manager in the offices of Messrs. Drake and Gorham, has been compelled to abandon the work on the advice of his doctors, and to go abroad. He proposes to start in business with Mr. Edlin, who has already established a connection in South Africa, and we wish the firm every success. The partners and employés of Messrs. Drake and Gorham have presented to Mr. Stevenson a Wheatstone bridge of the latest type, made by Messrs. Elliott Bros., and a handsome stationery cabinet, together with a letter of good wishes signed by members of the firm.

Aberdeen.—The question of the expediency of the Corporation introducing electric lighting into Aberdeen was under the consideration of the Gas Sub-Committee on Friday last. On account of the very unsatisfactory support promised to the scheme, it was resolved to advertise soliciting offers from private electric companies for the privileges conferred on the Corporation by the Electric Lighting Bill. Recently circulars were issued to 149 tradesmen, consuming £3,533 worth of gas per annum, asking if they were favourable to the scheme. Replies to the effect were received that seven people, consuming gas of the value of £139 per annum, agreed to adopt the electric light; 119, burning £2,530 worth of gas per annum, refused to have anything to do with the proposal; and 23, consuming gas of the value of £865, sent no reply.

South London Railway.—Before the East of Scotland Engineering Association Prof. A. C. Elliott, D.Sc., C.E., University College, Cardiff, read a paper on "The City and South London Railway." The lecturer referred to the history of railway tunnelling in connection with metropolitan railways, and described in detail this recently constructed electric railway. The number of passengers per day has already reached 16,000, and the fare, which is uniform throughout, is 2d. per head. He advocated the construction of these railways throughout the large cities of the world, and specially referred to the benefits of such a service for Edinburgh. A special feature in the City and South London Railway was its perfect ventilation. On the motion of Mr. A. R. Bennett, M.I.E.E., a hearty vote of thanks was awarded to the lecturer.

Telephoning to America.—Experiments have been in progress for some time, says a news agency (though where and by whom is not stated), to establish telephonic communication between London and New York. The idea was started long before the Paris telephone was successfully carried into effect, so that the present endeavour was not suggested by that event. Up to the present the attempt to talk across the Atlantic has not been successful, but this much has been accomplished—it has been found feasible to transmit sounds, though they are unintelligible. That is so far encouraging that it is believed it is only a matter of perfecting the mechanical means to establish perfect telephonic communication. It is probable that a specially constructed cable may have to be laid for the purpose, the experiments now, of course, being conducted over the ordinary telegraph line.

Westminster Electric Supply.—All the three stations of the Westminster Electric Supply Corporation, Limited, are now at work. The Millbank-street station was permanently started in November last, the station at Eccleston-place was started on the 2nd of March, and that at Davies-street, which supplies Mayfair (down to Piccadilly), was started on the 24th of March. In the two cases last named the permanent machinery is enclosed in a temporary iron building, covering over a portion of the engine and boiler rooms while the building of the rest of the station proceeds. The time which elapsed between the signing of the building contract and the delivery of current from permanently-installed plant was seven months and three days in Eccleston-place, and exactly six months in Davies-street, although work was practically stopped for nearly two months in the winter owing to the severe frost.

Italian Asbestos.—The United Asbestos Company, who supply Italian asbetos made into a multiplicity of articles, forward us their latest catalogue. From this we note that they have opened new branches in Cardiff and Bristol. The catalogue details and illustrates millboard and cloth packing for engineers' use, non-conducting composition for pipes, a new polishing soap (asbestolio); and a very good idea is that of fireproof asbestos ropes and ladders for use in fire-escapes. The greater part of the catalogue deals, of course, with asbestos packings—round, square, woven, or plaited. Asbestos gloves, aprons, and cloth, for furnace men; asbestos theatre drop-curtains are also a great point, and photographs showing scenery uninjured after a fire are given. The electrical department includes asbestos paper, tubes for electric light wires, cement, fireproof paint, strips, threads or yarns for covering wires, asbestos-covered wires, packing and jointing material, and a patent "Salamander" lubricant for dynamos.

Lighting up at Birmingham.—During the evenings of last week the public has had some opportunity of appreciating the excellent effect of indoor lighting given by the installations of the Birmingham Electric Light and Power Company. It has been thought well by the company's engineer, Mr. Vaudrey, to have an experimental lighting up before giving notice to the Corporation of the company's intention to begin supplying the electricity, and the experiment was carried on every evening. The current at 120 volts has given a very satisfactory light, and perfectly steady and constant. Among the consumers are the branch Bank of England, the branch offices of the Prudential Insurance Company, the Grand Hotel, Messrs. Sabin and Stockley, W. Wray and Son, Manfield and Sons, and others, and it is reasonable to hope that before very long all the shops and hotels in New-street and Corporation-street will be lighted with electricity. The company intend to begin to furnish their actual daily supply of electricity in a day or two, after the term of their notice to the City Council.

St. Pancras.—On Wednesday, to commemorate the success attending the electrical exhibition held in St. Pancras, and which closed last evening, a number of the exhibitors and members of the Vestry met together at a dinner at the Midland Grand Hotel. Mr. Churchwarden Boden presided, supported by Mr. Wetenhall, L.C.C., Mr. T. Howell Williams, L.C.C., Mr. Alderman Eccleston Gibb, Dr. Smith, Prof. H. Robinson, and Mr. R. W. Wallace. The last-named gentleman, in proposing the toast of the St. Pancras Vestry, congratulated the parish upon being the first to attempt the supply of electricity to the inhabitants. He spoke in commendation of the system adopted, which he believed would supply electricity suitable not only for lighting, but for motive power. That, he thought, would be very largely appreciated, as it would place within the reach of the parishioners a motive power which could be usefully employed in their homes. Prof. Robinson, as chairman of the exhibition, spoke of the success which had attended it, and, as the engineer responsible for the installation by the parish, said that he was firmly of opinion that before many months the authorities would be successfully supplying electricity at the rate of 6d. per unit. Before a year was over from the time of commencing he believed that every available unit would be in demand.

Paris Telephone.—On Monday the Paris telephone line was the subject of an interesting experiment. Five receivers were connected in the Post Office, and the other end was put to the Grand Opera at Paris. The orchestra could be heard so clearly that the separate instruments could be heard joining in. In a duet the two voices could be distinguished, and the applause of the audience and cries of "Bis" were also clearly heard. The transmitters were microphones, placed on the stage of the Opera House. On Tuesday the line was thrown open gratuitously, and numbers of business men availed themselves of the opportunity to test the line. On Wednesday the line was opened to the public, at the charge of 8s. for three minutes' conversation. A sound-proof box has been constructed of sheet lead and doehair to prevent any possibility of anyone overhearing private confidences of the Stock Exchange. A double pane of glass is fitted in the door, and an automatic electric lamp lights up on taking the seat. The influence of the sea in diminishing the volume of sound is very marked, as is seen in trying first to Dover and then to Calais. All day long messages were exchanged, but an unforeseen difficulty, alluded to in our leader, will obviously prevent a good many people from making as much use of it as they, perhaps, would have wished.

National Prizes.—Amongst the prizes proposed to be awarded in 1892 and 1893, by the Société d'Encouragement pour l'Industrie Nationale, are some for discovery in the fields of electrical and kindred sciences: Melsen prize of 500f. (1892), founded by Madame Melsens, to the author of an application of physics or chemistry to electricity, ballistics, or hygiene; also prizes of 2,000f. (1892) for a small motor for private workshops, working by itself or connected to a central station; of 3,000f. (1892) for the means of transmitting natural power over long distances; of 2,000f. (1892) for the industrial preparation of ozone and its applications; of 3,000f. (1893) for the discovery of a material which can completely replace guttapercha in at least one of its principal uses, or for work contributing to develop the production or improve the commercial employment of this gum; of 2,000f. (1893) for a commercial instrument or process for measuring or estimating the insulation of various parts of an electric installation when at work. Models, descriptions, information for those proposing to compete in 1892 must be sent in by December 1, 1891, which date will not be extended.

Chicago Exhibition.—Not the least interesting part of the great exhibition in Chicago next year will be the town itself, with its buildings 10, 12, even 18 and 20 storeys high, its magnificent parks, drives, and boulevards. The ground will be over 100 acres in extent. The Manufactures and Arts Hall will be three times as large as the largest building in the Paris Exhibition, measuring 1,700ft. by 800ft., with two interior courts and a great dome 350ft. in diameter. Two great piers in the grounds will enclose an artificial harbour, with a huge statue of Columbus, a full-sized American warship, and a reproduction of the fleet of Columbus. The administrative building, with gilded dome and statuary, will cost nearly 750,000dols. A natural island of 20 acres will be left in its primitive state in the centre of the lake. The transportation department will be an immense structure of iron and glass, with six parallel tracks and stations to avoid crowding, The Proctor Tower will be 100ft. higher than the famed Eiffel Tower, constructed of steel, and measuring 1,050ft. high. Reproductions of interesting and ancient buildings will be made a considerable feature. All the important buildings will stand on terraces 4ft. above the general level, thus adding to the imposing effect of what will evidently be one of the most gorgeous and magnificent exhibitions the world has yet seen—the fitting commemoration of the discovery of the New World, and abundantly illustrative of its extraordinary progress.

Electro-Harmonic Society.—A smoking concert will take place on Friday, April 10th, 1891, at the St. James's Hall Restaurant (Banquet-room), Regent-street, W., at eight o'clock. Artistes: Masters Dearden, Cooper, Wells, and Dalton; Mr. Wm. Nicholls and Mr. Frederick Bevan. Violins, Messrs. Jacques Greebe and T. E. Gatehouse. Violoncello, Mr. W. C. Haun. Piano, Mr. Alfred Izard. Humorous selections, Mr. Fred Cozens. Musical directors, Mr. T. E. Gatehouse and Mr. Alfred Izard. The following is the programme. Part I.: Part songs, "I would that my Love" "Maybells and Flowers" (Mendelssohn), Masters Dearden, Cooper, Wells, and Dalton; songs, (*a*) "The Rose is Beauty" (*b*) "Kate O'Flinn" (Haydn Parry), Mr. W. Nicholls; instrumental trio, "Andante and Molto Allegro Agitato" from trio in D minor (Mendelssohn), Messrs. Alfred Izard, T. E. Gatehouse, and W. C. Haun; new song, "The Flight of Ages" (F. E. Bevan), Mr. Frederick Bevan; violoncello solo, "Fantaisie sur Carmen" (Bizet-Hollman), Mr. W. C. Haun; musical sketch, Mr. F. Cozens; piano solo, Mr. A. Izard. Part II: Vocal polka, "Merry June" (Vincent), Masters Dearden, Cooper, Wells, and Dalton; old Irish song, "Gramachree," Mr. W. Nicholls; concerto for two violins, "Vivace," "Largo ma non tanto," "Allegro," (J. S. Bach), Messrs. Jacques, Greebe, and T. E. Gatehouse; duet, "The Moon hath raised" (J. Benedict), Messrs. W. Nicholls and H. Bevan; instrumental trio, "Finale" from trio in D minor (Mendelssohn), Messrs. Alfred Izard, Greebe, and W. C. Haun; song, "A life that lives for you" (Sullivan), Mr. Frederick Bevan; musical sketch, Mr. F. Cozens.

Richmond.—The feasibility or otherwise of lighting Richmond by electric light derived from water power, is discussed in the local press. A correspondent says: "Mr. R. F. Coles is the only gentleman who has taken the matter up. I quite agree with him that the idea of working a turbine with the water which escapes over Teddington Weir would not answer. In very dry seasons there would, in all probability, be an insufficiency of water for keeping the turbine constantly running, and this defect is likely to be intensified year after year from the increasing demands made at their intakes by the water companies. But how different will be the circumstances when the new lock and bridge are completed? From Isleworth to Teddington Lock, a distance of about 3½ miles, the tide will be penned back every 12 hours, and, as it were, one of the finest mile ponds in the world formed, which could be very gradually emptied twice daily. Is it not possible to construct valves either in the sluices, or in the supports of the bridge itself, which would regulate the escape of sufficient water to drive machinery for electrically lighting and supplying motive power at a very reasonable rate to the town and neighbourhood of Richmond? If the lock and bridge could not be used either by reason of the opposition of the Conservators, or from any insuperable legal objections, still it might be practicable to lead the water in pipes round the end of the bridge, and allow it, after turning the turbine or other requisite machines, to fall again into the bed of the river below the new lock. Since I wrote before I have consulted some engineers. They tell me that they can see nothing to prevent such a scheme from being carried out. One of them goes so far as to say that the reserve power of the water kept up by the lock would be so immense as not only to be sufficient for lighting Richmond, but other parts of London as well." It is just possible the idea may have something of the practical in it, and we recommend it to the notice of the makers of turbines.

Electric Lighting of Public Buildings.—Before the Institution of Engineers and Shipbuilders, held on Tuesday, Mr. Ebenezer Kemp presiding, a discussion took place on Mr. Henry A. Mavor's paper on "The Development of Electrical Distribution." Prof. Jamieson, C.E., F.R.S.E., of the West of Scotland Technical College, delivered a lecture on "The Electric Lighting of Public Buildings," giving prominence to the Athenæum installation, with which he was intimately connected as consulting engineer. He said that although a great number of towns in this country had obtained provisional orders for the purpose of supplying stipulated districts with the electric light, yet many public buildings, such as hotels, clubs, libraries, and concert halls, preferred to run their own installations. Unless the building to be lighted was one about to be constructed, wherein due provision could be made so as to readily accommodate all the generating plant without cramping, the engineer found himself confined, as a rule, in space and position to some underground cellar. In these circumstances he was often compelled to adopt arrangements which he otherwise would have avoided. Prof. Jamieson divided his subject into two parts. First, he considered the number of lamps and candle-power required, pointing out that, in order to obtain this, the engineer had not only to take into consideration the size of the respective rooms, but their special requirements. He gave rules by which he had been hitherto guided in determining these quantities, and explained how the 150-c.p. and 300-c.p. "Sunbeam" lamps were decidedly preferable to arc lamps, as well as to the small 16-c.p. or 18-c.p. incandescent lamps for reading and art rooms. Secondly, he considered the voltage, the current, and the power required for installations, dealing particularly with the electrical, mechanical, and commercial efficiencies of both dynamos and engines. Finally, he explained the general arrangements and details of the Athenæum installation, giving reasons for his plans, and pointing out that the unusual method had been adopted of placing the boilers, engines, dynamos, and storage cells all in one room, but he contended that in order to keep this plant in thorough order those in charge had in consequence to attend all the more thoroughly to their duties. The lecture was much aided by printed illustrations which were distributed amongst the audience.

Struck by Lightning.—A most curious and interesting case is recorded in the *Boston Medical and Surgical Journal* by Dr. L. M. Palmer, and recorded in the *Lancet*. It is noteworthy as being an accurate record of the experiences of a man who, while mowing with a two-horse mowing machine, was apparently struck by lightning, while the off-horse of the team he was driving was instantly killed. The men who were working near him said that he did not fall from his seat, but that his head simply tipped backward. When first seen by Dr. Palmer his pulse was 100; respiration 40 per minute and stertorous; the pupils were dilated; eyes fixed and staring; conjunctive insensible to touch; and there was general muscular rigidity. He was treated by hypodermic injections of brandy and ammonia, and at the same time was briskly rubbed, and his condition soon changed to that of constant restlessness. He had some bromide of potassium, and in an hour and a half was able to be moved in an ambulance waggon. On arriving home he vomited, and during the next few days he had several similar attacks. He passed a restless night, but became quieter in the early morning, when he for the first time recognised his friends and surroundings. On careful examination on the day after the accident there was found a gash in the occipital region 1½in. long down to the bone; the hair between the cut and the neck had been destroyed, and he had a burn in the left scapular region 7in. by 9in. There was a blister along the under part of the right arm, and a deep burn below the elbow over the fleshy part of the forearm. No mark could be seen beyond this. The crown of his straw hat was completely destroyed. He made a slow recovery, being troubled with noises in the head, deafness, a feeling of confusion, loss of memory, and general prostration. The right hand and arm were almost powerless, and he suffered from pain in the lumbar region and genitals. In 11 days he was able to sit up. In 10 weeks he could once more drive a team, but even so long as 14 weeks after the accident he was weak, walked as if he had lumbago, his right hand and arm were weak, and he had tenderness over the nerves of the right arm and forearm, and in the lumbar and gluteal regions. He also had great loss of memory. Looking at the serious and unusual nature of the accident, it is not surprising that his recovery has been slow, but as improvement seems still to be taking place Dr. Palmer hoped that it would be complete.

Electric Motors for Factories.—The loss of power incidental to the transmission of power by shafting and belts has, says a contemporary, often been referred to, and this well-known, but sufficiently appreciated, disadvantage has constituted a forcible argument in support of the use of independent motors, either employed directly to drive the machinery or to drive the separate lines of main shafting. In this connection the use of electro-motors is commencing to excite attention, for the method presents advantages which, in many situations, may render this form of power transmission the most economical and convenient. In a recent address before the Boston Society of Civil Engineers, Captain Eugene Griffin described a mill or factory plant where it had been estimated by competent engineers that, with belting and shafting in the ordinary way, from 30 h.p. to 50 h.p. would be required, and 15 h.p. in addition was necessary for lighting. But, as an actual fact, the motors are delivering about 50 h.p. to 70 h.p., though the energy developed runs an average of only 17 h.p. to 18 h.p. for 10 hours, owing to the immediate adjustment of the generating plant to the load, and the absence of long lines of idle shafting to be driven. Another example of this method of power transmission is furnished by the Globe Company's works in Detroit, in which case eight motors, varying from 1 h.p. to 15 h.p., have been in use for nearly two years. On the company's own showing, about 20 h.p. over the old style of transmission by belts and shafting is secured. Nor is this all, for they say that they are lighting their factory, a large building, with incandescent lamps, at no perceptible additional expense. It may be pointed out that in this installation it was arranged that the plant could switch its surplus current into the street incandescent mains if asked to do so by the electric light company. The loss due to shaft friction is, in many cases, far more considerable than is commonly supposed. In eight modern cotton mills fitted with first-class shafting, an average of 28·7 per cent. of the horse-power required for the whole load was found to be used by the shafting. In one instance, to drive the shafting alone took 36·1 per cent. of the whole horse-power, and in another 39·2. These figures are worthy of serious attention. With motors situated so as to drive short independent lines of shafting on each floor, part of this waste would still have to be endured; but the practice is growing of coupling the motor directly to the machine it has to drive.

THE ELECTRIC ARC AND ITS USE IN LIGHTING.*

BY ELIHU THOMSON.

(Concluded from page 325.)

In one form of regulator the effect is obtained by changing the field magnet strength by automatic mechanism, weakening the field when lamps are cut out and strengthening it when lamps are added to the circuit. Another means of regulation is the rotation of the commutator or brushes so as to take currents from positions corresponding to increased or decreased E.M.F. in such a way that the current obtained is constant. The former method first appeared in the Brush arc apparatus and the automatic commutator brush movement in the Thomson-Houston machines. The latter method renders the machine completely automatic under variations of load, while in the former there still is required a manual spark adjustment of the brushes as the field magnet is altered in force under different loads. The two methods were subsequently combined by the writer in conjunction with Mr. E. W. Rice, in such a way that the necessary brush adjustments were made automatically at the same time with the variations of the field under different loads. This combined method has been used for some time past in the Excelsior machines, constructed under the patents and designs of Mr. Hochhausen, whose name is so well known in connection with arc lighting, and plating, and other electric apparatus in this country. On account of the fact that with the addition of arc lights in a series a higher and higher potential difference is required at the terminals of the dynamo, it becomes a question how far this increase may properly be carried. It is not unusual in the present practice to run from 50 to 60 lights in a series, each demanding from 45 to 50 volts, or a total of, say, 3,000 volts. In going beyond this amount, the difficulties of insulation are greatly increased, as well as the dangers of high potentials, while the consequent risk of breakdowns resulting from failure of insulation or leakage are often sufficient to offset any saving of wire conductor that might be obtained by running more lights in series. Instances have occurred in which, with ordinary wiring and precautions, 120 to 150 arcs have been run for days together, but such a practice is to be condemned, as involving hazard of all kinds.

It has been supposed by some electricians that there existed a peculiar fitness for arc lighting in series in dynamos of the open-coil type, such as the Brush or Thomson-Houston over those of the closed-coil types, such as the Gramme or Siemens forms. While personally I have never been prepared to admit this peculiar fitness, constructors of machines of the closed-coil type have certainly succeeded in removing any doubts on that score. Mr. J. J. Wood has, in building his form of Gramme machine up to the highest capacities for series work, taken a leading position in this respect. In fact, the simplicity of the commutator and the ease of insulation of machines of the open-coil type undoubtedly rendered them more capable of retaining insulation at high potentials than the early commutators with numerous segments used on Gramme and Siemens machines, as such commutators were at first constructed. Likewise, improved methods of insulation and winding have gone far to put both types of machine far in advance of what they were formerly. While on this subject of arc machines, it may be well to say a few words as to the action of flashing, which can occur in all machines of high potential under certain conditions. In the first place, the term flashing, as here used, is not intended to refer to sparking at the commutator, but rather to a flash or continued spark carried over during revolution of the armature from one brush toward the other, either all round the commutator or part way only. This action occurs when any two successive segments in the commutator continue their discharge one toward the other over the insulating space between them during a considerable part of the revolution. An arc forms in the slots or between segments and moves with them. This action, while not very damaging where the segments are massive and isolated with air spaces, is more serious with insulation filling between the segments, as it is apt to cause a burning out and either short-circuit the armature coil sections by connecting the segments or seriously roughen the edges of the segments and the face of the commutator.

Bad setting of bushes may both cause sparking as well as flashing; and dirt, in some cases, or too much oil, may cause it. Slipping of belts or sudden fluctuations of speed may also provoke it. Or a machine overloaded may flash by an opening of circuit due to too many lamps, the E.M.F. required for which number the machine cannot maintain. The presence in a circuit of one or more lamps which do not feed properly may cause momentary cessations of current and flashing to occur, especially when the machine is carrying its full load. With all arc circuits there should, of course, be a surplusage of capacity on the dynamo—*i.e.*, the machine should not be run to the limit of its E.M.F. It has become customary with the best makers to so rate this capacity that there will always be a margin of excess to meet contingencies. The line resistance may, of course, be, in the case of long circuits, such as to cut down to a considerable extent the working capacity or number of lamps in series which can be run from the dynamo, and due allowance should always be made for this resistance in estimating the true capacity. Instances are not uncommon in which by improving the contacts of switches, hangers, joints, etc., a gain of two or three lamps may be made in circuits of 50 or more lamps in series. An improvement in the insulation of a line will often have a similar effect in adding to the apparent capacity.

I had intended at the outset of this paper to discuss in a general way the question of the different types or classes of lamps used for arc lighting. It is a department of the subject which is of considerable importance, but I find that the paper has become too long already, and for the present I will simply allude to one or two general features. Concerning the manner of feeding the carbons, the mechanisms in use may roughly be divided into clutch and gear mechanisms. Among clutch mechanisms we find certain well-known forms, while the gear mechanisms best known are of the escapement order. Both types have undergone many modifications, and combinations of the two exist.

Whether one or the other type is to be selected will depend largely on the conditions of use, assuming both to be equally well constructed and kept clear. Into these questions, however, we cannot now enter.

Arc lamps may also be divided according to the way in which the magnet system acts to control the feed of the carbon. Before arc lamps were run in series it was sufficient to have the controlling magnet in the main circuit, and this was the case in almost all the older forms of lamp. The Lacassagne and Thiers lamp of 1856 was a notable exception, in that the control of the feed was differential or dependent on the different power between a main circuit coil and a high-resistance shunt circuit around the arc.

I have, in fact, made an exact reproduction of the Lacassagne and Thiers lamp according to their patent specification, and have found that its action is perfect when used in series with other lamps, except that it requires to be helped to separate its carbons. If the carbons are quite pointed at the start even this is unnecessary, as the points soon heat and burn away and form the arc. The feeding depends on the flow of mercury through a small valve, which is adjusted by the differential magnet system, and the feeding is so continuous and imperceptible that the arc is beautifully steady and constant in length.

At the present time the differential lamp magnet system is of several kinds, according to the relative disposition of the main and shunt coils.

In the commercial Brush arc lamp they are disposed one over the other on the same axis, and affecting the same magnetic cores. The only objection to this disposition, which has the advantage of simplicity, is that the shunt circuit can never act positively to feed the carbons or release the clutch or gear, but can only weaken the effect of the main coil or overpower its lighting or separating action on the carbons.

Other forms of differential lamp embody the two circuits acting on separate magnets pulling in opposite directions, the main circuit to separate the carbons and the shunt to feed them. In this case the action of the shunt is more definite and positive, as it is not limited simply to overcoming the force of the direct or main magnet.

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* Paper read before the Providence Electric Light Convention.

A third arrangement involves the application of the repulsive action of the two coils, as when the direct coil is wound on the fixed magnet and the other, or shunt, upon the feed controlling armature therefor and tending to cause repulsion of the armature from the main magnet. This arrangement is both simple and positive in its action.

The differential types of lamp act well when the circuit current is kept constant, and require readjustment generally for each change of current strength by which they may be operated. Hence, if a portion of line be leaky the lights are apt to burn badly, owing to diminished current, while the dynamo may be furnishing full current. Of course such a line ought to be condemned and its insulation improved. Nevertheless I have frequently seen lights suffer from leakage on extended circuits in cities, especially in very wet weather. This is a state of things which the line superintendent can do more than anyone else to correct by attending to the correct disposition of the wiring, and its character as regards leaks.

The type of arc lamp in which the shunt magnet alone controls the feed of the carbons is not sensitive to slight variations of current, but maintains a full, quiet arc with the current it gets. This is because the main current is not concerned in the feeding action, but the action is solely dependent on the potential difference of the carbons. Hence its behaviour is, on the whole, more uniform than the differential type, and within limits it does not require readjustment for different current strength.

This principle has been extensively introduced in the Thomson-Rice lamp of the Thomson-Houston Company. In this lamp the carbons are separate at the start and are brought together on the first passage of the current, after which they separate solely under the influence of the shunt circuit magnet, and the feed is likewise controlled thereby. The carbons in these lamps are not so apt to slide by or alongside each other by jarring when no current is on the lamp, as may occur, particularly with careless trimming, in those lamps in which the full weight of the upper holder and carbon must be borne by the under carbon when the lamp is not lighted.

Arc lamps have been made with many variations in the magnetic arrangements controlling the carbons, a brief statement of some of which is as follows: Carbons lifted or separated by direct or main magnet; shunt magnet acting on a variable resistance to cut out the main magnet in feeting. Carbons lifted by main magnet as before and shunt acting to put the main magnet (made movable) into position for feeding.

Carbons separated by main magnet armature; shunt circuiting magnet acting to divert or shunt the magnetism of the main magnet from its armature.

Carbons separated by main magnet and shunt acting to free the carbon-holder independently of the support given by the main magnet.

Carbons separated by a spring allowed to act by the main magnet lifting a weight which otherwise holds the spring from acting; shunt magnet acts against the spring to feed and regulate length of arc.

One carbon, generally the lower, separated by main magnet, while the other holder is released for feeding only, such feeding being under the control either of a differential system or a shunt magnet only.

Carbons separated by main magnet, which lifts the shunt and its armature together, while the shunt magnet armature acting on the feeding mechanism controls the arc and feed of the carbons.

Carbon feeding mechanism independently attached to main magnet armature and to shunt armature, so as to receive opposite movements of separation and feed from each respectively.

Carbons separated by a feeding mechanism moved by the main magnet and fed by a further movement of said mechanism, causing release or return of same under the accumulated force of both shunt and main magnets acting in the same direction.

Differential clock gear for separation and feed of carbons under control of the regulating magnet system, either simple or differential. Some of the older clockwork lamps embodied this principle.

Carbons controlled by armature of a small electric motor under control of a differential field which turns the armature in one direction for separating, and in the other or reversed direction for feeding the carbons. Tchikoleff's early lamp was of this type.

Carbons controlled by a motor running at a certain speed when the arc is of normal length and varying in speed when the arc is too short or too long, combined with a centrifugal governor on the shaft of the motor acting on variations of speed to gear motor shaft to screw carbons together or apart as needed to maintain the normal arc. This mechanism has been applied by me to large arc lamps, such as naval-search lights, and has the advantage of great positiveness and an ability to handle heavy mechanism.

There are also a considerable number of modifications from these principles stated which cannot be referred to here.

Another excellent mechanism, and one of the most powerful and positive in feeding the carbons, embodies a main magnet separating the carbons and striking the arc, and an intermittently-acting shunt magnet for working a pawl, which by a suitable gearing forces the feeding action on approach of the carbons as required. I have used an endless screw gearing with the pawl acting on a ratchet wheel to turn the screw, the worm wheel being on a shaft carrying a pinion meshing into a rack on the carbon rod. The worm wheel gearing is lifted by the main magnet to strike the arc, and the shunt magnet, in operating its pawl, breaks its own circuit, and repeats its feeding action as often as may be necessary.

It is interesting to note in this connection that I have built such lamps in which each feeding movement of the carbon is not over $\frac{1}{5000}$ of an inch, and that if the upper carbon rod is held in a vice the mechanism will lift the whole lamp, of about 20lb. weight, in feeding, so positive is the action. At the same time the length of the arc is maintained constant at all times. With so slight and yet positive a feeding action the feed takes place almost continuously.

In the foregoing brief review many matters have been simply touched upon which might readily have been singly expanded into a paper as long as the present one. Material enough now certainly exists and could be collected for making a good technical work dealing with the science and practice of arc lighting. My purpose will have been fulfilled if I have succeeded in the present paper in adding some things of interest and instruction concerning this general subject from the standpoint of one who has constructed very many forms of apparatus for arc work, and who has had a continuous and growing experience with such work from its beginnings up to the present great commercial expansion.

TRANSMISSION OF POWER BY ROTARY-PHASE ALTERNATE CURRENTS.*

BY M. VON DOLIVO-DOBROWOLSKY.

The progressive development of industry in general, and of electrical industry in particular, is leading to a constantly increasing application of the electric transmission of power. At the time of the Munich electrical exhibition the experiments of Marcel Deprez were taken up with great rejoicings, and there was already a presentiment that the new-born child would at once develop quickly and powerfully. The following years passed away without anything further occurring in this department, the pause being essentially caused by the low efficiency and unsafe working of the dynamo as then made. In the years 1886 to 1888 the work and endeavours of the English school of electrical engineers so improved the dynamo and the motor as to render possible economical transmission of power. The Oerlikon Works during this time did good work in this field. But continuous currents being little suited for long-distance distribution and transmission of power, in consequence of the delicate nature [illegible] of difficulties in alternate current transformation, the bold desires of electrical engineers remained still unfulfilled; to build a continuous-current dynamo of 1,000 to 2,000 volts for feeding single motors and lamps is almost impossible nowadays, and will almost certainly remain so. Though we do not by any means desire to deny to the continuous-current dynamo all its good qualities, yet we must point to the alternate current as the only suitable one for extensive distribution of energy. But until a short time ago there was no practicable alternate-current motor, and consequently many prominent engineers and scientific men directed their attention upon this region of investigation. Yet all these efforts remained without success up to the year 1888, which may be admitted as the initial year of transmission of power by alternating currents. Ferraris's discovery, Schallenberger's and Tesla's researches were published almost together in 1888, while many others were working upon the same principle of different phase alternate currents, without, however, arriving at any practically useful result. Tesla's motor, which on its appearance was written up and discussed so much, seems, however, to not have fulfilled the expectations excited; in spite of the years since elapsed, there has come no notice of any serious application of it. As will be later proved, Tesla's arrangement, with two entirely independent currents differing by 90deg. in their phases, was not particularly advantageous; its faults were avoided in other arrangements, and motors with a greater number of alternate currents were contemporaneously studied by Bradley, and the present writer, Haselwander, and Wenström. At the same time (October, 1888) as Bradley applied for the American patent for his three-wire connection from a Gramme armature, the present writer also was working in the Allgemeine Elektricitäts Gesellschaft on a three-phase motor, and Haselwander was also experimenting at Offenburg. In March, 1889, the Allgemeine Company applied for a patent on this subject; in consequence of some formality or error, the patent was only partially granted. As the preliminary measures for constructing such motors and some improvements in details claimed the whole time of this firm, the second amended application was kept back till August. During this pause—namely, in June—Haselwander made an application for a patent bearing on the same subject. Though the three-phase current system, as it is at present applied, essentially differs from that originally in view (and, therefore, also from the system of the above-mentioned inventors), yet the author believes to act in the interest of the "rotary-current" (as he would like to propose to term the multiple-phase current) in communicating these episodes in the progress of its early development. In the same historical interest the author believes he is justified in stating that Bradley's first publication appeared towards the end of the summer, 1889, while already in the beginning of the summer, 1889, in the Ackerstrasse Works of the Allgemeine Company, a three-phase motor and a 6-h.p. rotary-current dynamo were brought before some well-known and prominent electrical engineers. In the spring of 1890 some foreign rotary-current patents were printed, while the specification of Haselwander's patent, applied for in the month of June, 1889, was given to the public; but in the summer of 1890 Wenström's applications for foreign patents on the same subject (being in 1890) do not come into consideration in the question of priority. Altogether it is extremely difficult, out of the crowd of suddenly published researches and applications for patents, to definitely adjudge the priority of the idea to the one or the other of the inventors named with regard to such an invention, which was, so to speak, in the air, and especially because, as we have seen, these inventions emerge so suddenly one after the other that the independence of each inventor cannot be called in question. But the technical priority incontestably belongs to the person and the firm who gave vitality to the invention, and who first produced a useful technical piece of apparatus out of a thought and an experiment. Though the scientific value of the discoveries of Prof. Ferraris and Mr. Tesla must not be lessened, yet the merit of the practical working out and execution of the rotary-current system is indubitably due to the Allgemeine Electricitäts Gesellschaft. It was this firm that brought the whole system to such a pitch of perfection as to render possible the boldest enterprises in this direction—such as the transmission of power from Lauffen to Frankfort. Besides this plant designed for the Frankfort Exhibition, there are now being carried out quite a number of large installations for the distribution of power—as, for instance, the utilisation of the water power of the Rhine at Rheinfolden, for Basle and the neighbourhood; a distribution of power and light in the town of Heilbronn, from water power at Lauffen; and a transmission of some hundreds of horse-power from Bülach to Oerlikon—all of which plants are being carried out by the Allgemeine Company of Berlin, in conjunction with its licensees, the Oerlikon Works of Zurich.

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* Translat[illegible]

As the author reserved to himself a detailed description of his rotary-current system for the description of the transmission plant sent to the Frankfort Exhibition shortly to be opened, he gives here, therefore, only the essential outline of this system, with diagrams, together with some tests carried out upon a small 2-h.p. rotary-current motor.

(To be continued.)

THE FERRANTI METER.

We were favoured last week with an invitation to inspect the works of Messrs. S. Z. de Ferranti and Co., Charterhouse-square, Smithfield, for the purpose of inspecting the manufacture and testing of the new Ferranti meter. The meter department is organised in a top storey of the large works, and is specially fitted with extremely interesting automatic clockmaking machinery of American manufacture for making the trains of gears. These parts are thus made in considerable numbers, and such is the delicacy of the gearing due to the automatic workmanship and the burnishing of the teeth, that the slightest puff from the breath will set the wheels rapidly spinning.

The meters are made in two types for large and small currents. One of these, the larger, is formed of semicircular poles (partially choked by copper segments), which act inductively upon a rotating ring of copper or gunmetal. A small type of alternate-current motor for fans is also being made on this model. These meters are made for 40 amperes and upward.

The smaller type is that illustrated by us a week or two ago, and comprises a permanent steel magnet arranged with an exterior tube as one pole, and an interior projection as the other, the interstice being wound with a coil of wire. In a small space above, mercury rotates, more or less rapidly in proportion to the current passing, the permanent magnetism enabling it to start very easily. A minute fan of flat platinum geared to the light train of wheels is placed within the mercury and rotates with it. These meters will read up to 10 amperes.

Tests were made in our presence and the fact was demonstrated that these meters will actually start with a current of ·1 ampere and will rotate noticeably with ·2 and ·3 of an ampere. An 8-c.p. lamp at 100 volts requires at least ·35 ampere, so that every requirement in practice as to the starting is thoroughly well obtained. With reference to this point of immediate starting, the following interesting calculation has been made by Messrs. Ferranti and Co., which, although taken arbitrarily, shows the extreme importance of accuracy in an electricity meter:

Distributing companies supplying current to 40,000 lamps of 8 c.p., or rather their equivalent in various sizes, are now numerous. If these lamps are divided among 800 consumers, and, taking only so small a quantity as 1 ampere for one hour each day as that which passes unrecorded in each case, the loss to the company would be £973. 6s. 8d. per annum, the current being supplied at 100 volts, and charged at 3d. per unit.

A single lamp, or perhaps two, are kept alight nearly all day, and sometimes all night, either by design or accident by a very large number of consumers, consequently, unless their meter records accurately at low readings, the loss to the distributing company will most probably be greater than that estimated above.

Mr. Ferranti has from the first appreciated these considerations, and the success which he has attained in his meters is shown by the fact that the 10-ampere size starts with ·2 amperes, the 40-ampere with ·3, and the 100-ampere with ·5.

In the continuous-current form of the Ferranti meter the magnets are of a special steel, the residual magnetism of which provides the initial field which enables them to start at such exceedingly low readings.

In the alternating form this is not possible, but the same effect is attained by the use of a fine wire coil, through which a minute shunt current passes round the iron core and produces a strong magnetic field relatively to the small current passing through the meter at low readings. The resistance of this shunt is 8,000 ohms, consequently the current passing through it at 100 volts costs the distributing company, at 3d. a unit, under 7s. 6d. per annum, but the great saving which it effects is a twofold compensation for this.

SOME RECENT IMPROVEMENTS IN LEAD SECONDARY BATTERIES.*

BY J. T. NIBLETT, MEMBER.

(*Continued from page 315.*)

Reynier's Accumulators.—Emile Reynier has given much attention to the production of secondary batteries of the Planté type. One of his early forms of plate consisted of a thin sheet of lead folded up zigzag fashion, and then encased by a stout cast leaden ring. By this means he obtained a very large active surface in each plate. During its formation the fluted interior of the positive plate expands considerably, but meeting with opposition from the rigid sides it does not warp or buckle, but merely tends to close in upon itself, and to partially fill up the interstices. Owing to the large expansion ih this form of plate, it was found necessary to make the outside lead rim strong, and therefore heavy. To decrease the weight and yet retain the same degree of strength, he substituted for the lead, light iron or steel frames, dipped in molten lead, or an alloy of lead and antimony. Another form had a long lozenge-shaped hole in the middle of the element. This hole gradually closed up as the fluted lead sheet expanded. Another and more recent form of battery devised by Reynier is now receiving much attention in France. He calls his new battery an "elastic" accumulator, from the fact that means are taken to allow the elements to expand or contract during the charge and discharge without in any way damaging the plates. With this view he now separates the electrodes by means of thin porous sheets of silica, which only slightly increase the internal resistance of the cells. Each cell is composed of one positive and two negative plates, and of four sheets of silica, the two end sheets of silica being fluted so as to increase the space available for the electrolyte, the quantity of which, however, is small. The containing vessel is of sheet iron, lined with indiarubber, and it is therefore both light and elastic. A still later type of containing vessel is made of pure lead, the necessary flexibility being obtained by surrounding the lead cell with an expansible corrugated case. The plates themselves are made up of very fine lead wires woven into a net, and slightly compressed into the desired shape. A battery of 20 elements is about 50 centimetres long; during the charge the plates increase in volume to the extent of about 6 per cent. The inventor asserts that the new elastic cells are capable of giving an output of 30 ampere-hours per kilogramme of plate, or 20 ampere-hours per kilogramme of total weight. The batteries as now made, Fig. 7, are composed of a number of cells connected in series, and placed between two rigid end pieces drawn tightly together by strong indiarubber springs. The contractions and expansions of the elements can take place freely without disintegrating them, owing to the action of the springs. The spring arrangement gives the active material considerable artificial elasticity, which enables one to use this class of cell for purposes where they are liable to receive rough treatment, or where cells are required to give a high output for a limited weight of cell.

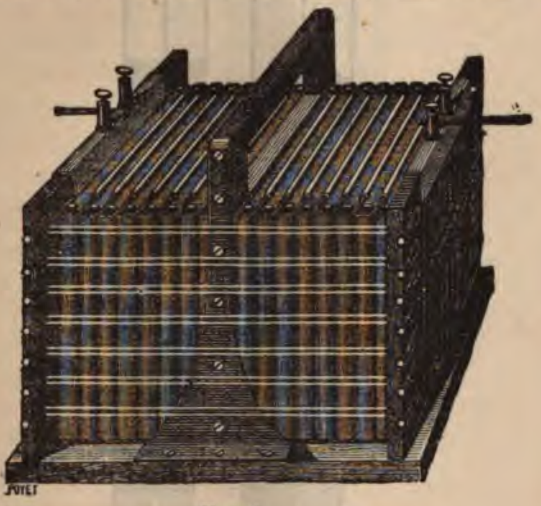

FIG. 7.

Some very useful general information on the subject of storage batteries may be obtained from Emile Reynier's work entitled "Voltaic Accumulators." This book has been translated into English by Mr. J. A. Berly. The way, however, in which the French text has been transcribed into this language is rather curious.

Elwell and Parker's Cylindrical Elements.—Some years ago Messrs. Elwell and Parker constructed a large number of storage batteries of plain or perforated tubes or cylinders. The cells were made up of a series of these tubes placed one within the other, alternately a positive and then a negative. A clear liquid space of about ½in. around each tube was allowed. By a system of charging and reversing, these lead elements ultimately acquired a considerable current capacity. This form of battery was much used in the early days of electric lighting as regulators for the dynamos. If the cells sulphated at any time it was usual to run them down gradually, and then finally short-circuit them. After this the current was reversed, and in a few days the battery would be capable of taking up its full original amount of current.

Cheswright's Improved Planté Elements.—This form of battery, as made by Messrs. Betts and Co., of Carcassonne, is somewhat novel in construction. The metal used for both elements is pure, specially refined, sheet lead. Each element is so constructed that its interior is quite hollow, and is divided into vertical chambers by thin lead partitions running throughout the whole length of the plates. By passing the lead sheets through suitable shaped rollers each surface is closely corrugated into a series of raised dovetail-shaped rims. During the rolling process the lead is subjected to great pressure, which tends to close up the grain or pores of the metal, and make it both dense and elastic. The flutings on the spongy lead plate, Fig. 8, are made as closely together as possible, while those on the peroxide plate, Fig. 9, are somewhat wider apart. During the formation of the positive plate the metal, as it is being converted into the peroxide, expands, and the active material wedges itself into the dovetailed grooves, thus securing itself against disintegrating influences. Owing to their elasticity these cells are said to be capable of withstanding very rough treatment. In building up the cells a number of these hollow plates are fitted into a stout wooden frame, and are held in their proper position, and the requisite distance apart, by means of stout cross-bars made from the substance of the plate, and being part of it. These cross-bars drop into recesses made in the top of the wood frame, and securely hold the plates in their respective positions. As the whole system of plates is firmly fixed to the wood frame, they may at any time be removed from the glass containing cell for inspection purposes without fear of damage.

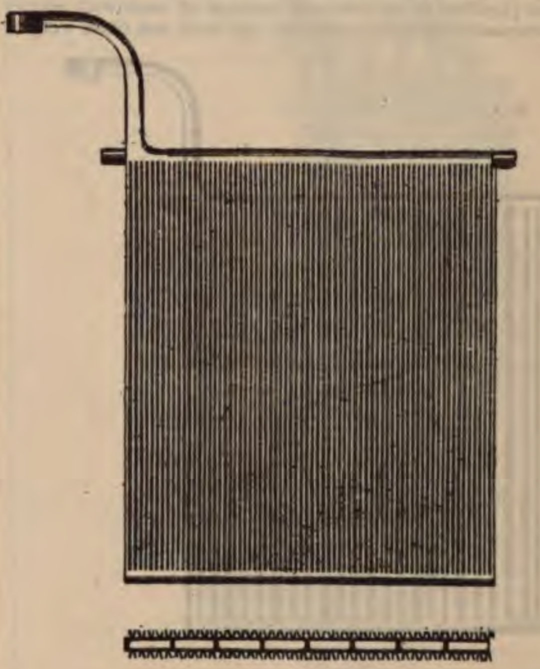

FIG. 8.

Having now drawn your attention to some of the most noteworthy and interesting developments of Planté's original lead cell, I shall proceed to point out some of the most important modifications of the pasted, or Faure type of cell.

In addition to those already enumerated, there are many other forms of storage cells well worthy of notice, but as they are chiefly combinations of el [illegible] ad and carbon, oxide of co [illegible] r combinations of t [illegible] and many other metallic and non-metallic substances; reference to these would be somewhat out of the scope of this paper.

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* Paper read before the Physical Society of the Glasgow University, 13th January, 1891.

Some very interesting results have been obtained by replacing the ordinary dilute sulphuric acid, by solutions of soda and potash, also magnesium and mercuric salts and other substances.

Camile Faure, seeing the great loss of time, and the many inconveniences of Planté's method of forming secondary battery elements from plain lead plates, conceived the idea of accelerating their formation by applying a layer of chemically-prepared oxide of lead to the surfaces of the metal. He coated lead plates thinly with a paste of the red oxide of lead, or minium, moistened with acidulated water. When dry these plates were placed in a bath of dilute sulphuric acid, and were then subjected to the electrolytic action of a moderately strong electric current. To prevent the disintegration of the lead salt, he interposed between the plates a thickness of porous felt or cloth. After the passage of the electric current, he found that the oxide on the positive plate was converted into peroxide of lead, while the salt on the negative element had been reduced to finely-divided or porous lead.

It was soon found that by repeated charging and discharging the loose oxide tended to permeate through the pores of the felt, and thereby caused the formation of lead trees. These minute lead bridges caused serious short-circuiting and the ultimate destruction of the elements.

To most members of this society Faure's first battery must have a special interest. It was to the Glasgow University that his first battery was brought, and it was here that the original investigations were made. I daresay most of you will remember the amount of interest excited by the appearance of Sir William Thomson's description of the "Faure" cell in the *Times*, now about 11 years ago. In his letter Sir William related how, for the first time, it was possible to store a vast amount of electrical energy within a comparatively small compass, and with but little weight.

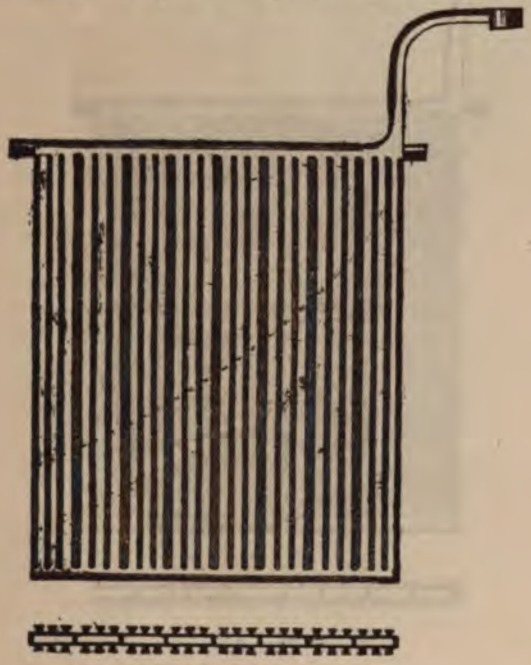

FIG. 9.

Many months before the new battery was commercially exploited, both Sir William Thomson and Dr. J. T. Bottomley thoroughly investigated it. It was then that Sir William suggested the "cup" secondary battery element. Some years ago, while in one of the storerooms near the tower of this building, I came across a number of the original experimental secondary battery plates, and I well remember that some of those plates bear a striking resemblance to certain so-called recently-introduced improvements.

Much ingenuity has been exercised in devising methods of holding active materials on to metallic accumulator elements. Messrs. Sellon, King, Volkmar, Philippart, Parker, Swan, and others, have each taken out patents for various forms of grids, frames, or plates. These patents, combined with Faure's original discovery, constitute that group of inventions owned by the Electrical Power and Storage Company,* and known shortly as the E.P.S. patents. Accumulators made under the above patents have now been extensively used for many years, both in this country and abroad

After the experience gained by a very large number of experiments, the present form of grid was adopted, Fig. 10. The usual method is to cast the plates in an iron or steel chill or mould. The plate now in use is perforated with a large number of square apertures—these holes are tapered inwards from both surfaces of the plate, thus forming a double dovetail. Owing to their peculiar shape, the pellets of active material tend to key themselves firmly into the countersunk holes. A still more recently improved plate, just introduced by this company, has a very thin perforated film of metal running across each aperture midway between the outer edges. The negative plates are made of pure lead, and the positives of an alloy of lead and antimony. The antimony serves to make the grids hard and less liable to bend, and at the same time it prevents the "eating-in" action of the acid and current. The metal antimony is not dissolved by a sulphuric acid solution, nor is it much affected by the electrolytic action. When cool and cleaned up, the grids are filled in with a paste made by adding to minium water acidulated with sulphuric acid. The paste is pressed into the apertures by means of a trowel, and the superfluous material is scraped off level with the metal of the grid. When dry the plates are placed in a bath containing dilute sulphuric acid, where they are partly formed, or what is known as "hardened," by means of an electric current. Minium is used for the positive and litharge for the negative plates. After being hardened, the plates are removed from the bath and placed into a suitable frame, and their connecting lugs are burned together. When treated as above, the elements are fit for sale purposes. In all cases the actual forming is done by the purchasers.

As most of you are doubtless quite familiar with the various forms of the E.P.S. batteries as supplied either by Messrs. Drake and Gorham, Elwell-Parker, or by the company themselves, I will not weary you by enumerating the many modifications which this battery has undergone in adapting it to the almost endless purposes to which this form of storage battery has been applied. Much has been written on the subject of accumulators of this type, chiefly giving the results of personal experience gained in the specific application of these batteries for electric lighting and traction purposes. For those desirous of learning more about the E.P.S. batteries, I would suggest the perusal of Sir David Salomon's very useful little hand-book, entitled "Management of Accumulators." This book contains much really practical information on fitting up, charging, and testing accumulators, together with much general information as to their management. In the year 1881, Prof. Silvanus Thompson read one of his always lucid papers on the "Storage of Electricity," before the Sociey of Arts in London. To the same society Prof. Oliver Lodge gave two lectures on "Secondary Batteries," in the year 1883. On May 1, 1889, Mr. W. H. Preece, F.R.S., read a most instructive paper, entitled "Secondary Batteries," before the same society.

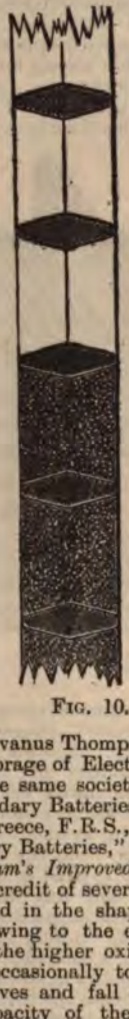

FIG. 10.

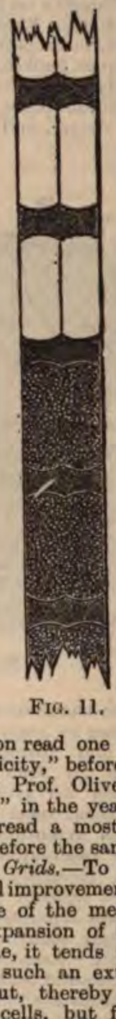

FIG. 11.

Drake and Gorham's Improved Grids.—To Messrs. Drake and Gorham is due the credit of several improvements, both in methods of manufacture and in the shape of the metal holders for the oxides of lead. Owing to the expansion of the minium during its conversion into the higher oxide, it tends to expand on both sides of the grid, occasionally to such an extent that the little pellets split in halves and fall out, thereby not only seriously decreasing the capacity of the cells, but frequently bridging across the plates and causing bad short circuits. To prevent this, Drake and Gorham pass the cast-metal grids between rollers and burnish down the outer edges on both sides of the plates, thus forming a sort of double dovetail in each aperture, Fig. 11. By this process the tendency of the pellet to fall out is practically overcome.

Eickemeyer's Storage Battery.—In this form of battery the cast lead plates are provided with a number of polygon-shaped holes, instead of the truncated squares. Each opening is filled in with oxide of lead made into a paste by the addition of acidulated water. The pasty mass is well pressed around plugs, which, when removed, leave circular openings in the centre of each pellet. Each plate has a projecting terminal and all are counterparts cast from the same pattern, so that when reversed in position and piled one on another with the terminals located alternately on opposite sides, the holes register with corresponding holes in all the plates throughout the pile. Between each two plates there is placed an insulating plate, which is also provided with holes corresponding to those in the lead plates. With the battery thus constructed, each vertical line of holes constitutes a chamber for containing the electrolyte, and this is supplied by means of a funnel which tightly fits the feed aperture at the top. As the liquid falls to the bottom of the battery, it is distributed by way of lower channels and openings in the base-plate to the several cells, in which it rises with uniformity until all are properly filled. An extensive area of the porous material is thus exposed to the electrolyte, and the metallic lead of each grid is completely protected against the liquid except through the active material. Mr. Eickemeyer has designed various forms of these cells, all embodying the same principles, and resulting, it is claimed, in a cell of considerably reduced weight in proportion to its storage capacity.

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* Now called the Electric Construction Corporation.

Tudor's Elements.—To accelerate the formation, Tudor deeply grooved his lead plates by passing them between suitable metal rollers. The grooved plates are then coated by electrolysis with a thin layer of peroxide, and the interstices are filled in with an oxide of lead. The idea of coating the lead with peroxide is to prevent sulphating at the junction of the metal and the oxide. When the plates have been treated as described, they are then dried, and again passed through smooth rollers. This last process closes up the grooves, and tends to key the oxide in, and thus prevents scaling.

The *Electric Storage Battery Company*, of Philadelphia, find that active material made from a chloride of lead gives the best results. To obtain the chloride, commercial lead is melted and converted into a finely-divided powder. The lead is then dissolved in nitric acid, and is precipitated by the addition of hydrochloric acid. The chloride is then thoroughly washed and brought to a molten state in a furnace. The fused mixture is poured into square moulds and allowed to cool. The square blocks of chloride so formed, and which are destined as the active matter in the plates, are then placed in a mould prepared for their reception, and a grid of lead is cast around them. The grids are then packed between zinc plates and placed in a tank containing dilute chloride of zinc. There is thus formed a voltaic couple, the action of which is to dissolve the zinc chloride, and to extract the chlorine from the lead chloride contained in the blocks. The last trace of chlorine is removed from the plates by washing them, then placing them in a vessel containing nitric acid and passing a current. This action also opens the pores and leaves a pure lead sponge in the grid. The plates for the positives are packed tightly between perforated ebonite boards and formed into peroxide in dilute sulphuric acid.

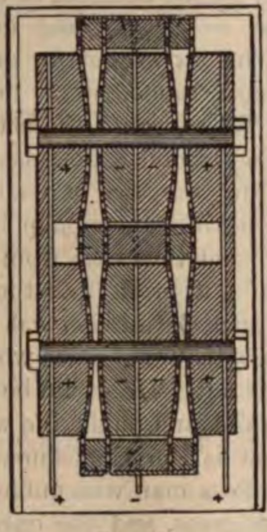

Fig. 12.

Hering's Accumulator Elements.—Mr. Carl Hering has given some attention to methods of preventing the buckling and warping of secondary battery plates. To this end he constructs cells having but four elements, two positive and two negative, Fig. 12. The two outer plates are solid blocks of lead peroxide, such as may be made by mixing lead oxide in a solution of salts of lead, pressing the mixture in a mould and forming it into the shape desired. The two inner blocks are of spongy lead. These blocks of lead and peroxide are not fastened permanently to any electrode: they are simply held in contact with the contact plates of lead or lead alloy, which lie against the flat sides of the blocks of active material, and project through the top of the cell. The means taken to secure proper contact are simple. Perforated straps of non-conducting material pass over the exposed surfaces of both positive and negative plates, keeping the plates firmly in contact with the removable electrodes and at the same time preventing them from touching each other. These batteries can readily be taken apart; a single plate can be removed, if injured, and another substituted with very little trouble; and, in addition, it may be noted that the active material is formed in a block by itself, with which contact is afterwards made, instead of being mechanically applied to an electrode, as in the majority of other storage batteries. Owing to the relative smallness of surface, the internal resistance of this form of cell must be somewhat high.

Gibson's Battery.—The idea in this form of battery is to construct in a simple and economical way an accumulator capable of withstanding a considerable amount of rough treatment without the active material being jolted out or disintegrated. The plates are formed from the ordinary rolled sheet lead. A large number of small loops are forced or stamped out from the substance of the element itself. Parallel rows of these projecting loops extend across the plate, each alternate row being a half loop in advance of the others. To add strength to the plates, the edges on all sides are turned up in the form of a rim. After the stamping process the elements are filled in to a uniform level, either with oxides of lead in the form of a paste, or the oxide merely damped and then pressed in. By the arrangement of loops, the active material is effectually keyed in. When setting up the cells, the plates are placed horizontally one above the other. A number of vulcanite pins are studded over each plate and serve to keep them the requisite distance apart. Owing to the relatively large amount of active material on each metallic support, it is asserted by the inventor that his form of cell gives a much higher capacity per pound of plate than the ordinary grid form.

Hatch's Accumulator.—This somewhat novel form of battery has just been introduced into America, where it is known as the "Cambridge" accumulator. In this form of element, lead is not employed for supporting the oxides or spongy lead, but is used simply as a conductor. The active material is supported by a porous earthenware plate which is corrugated zigzag fashion, and is made of extremely open-grained material. When the corrugations in the earthenware plate are filled up level with active material, the lead conductors are inter-leaved between each block, alternately a plus and then a minus plate. The metal plates are made of an alloy of lead and antimony. In a 200 ampere-hour cell, Fig. 13, the porous plates are 7in. square and ½in. thick, outside measurements, and the corrugations are about ¼in. deep. The plate weighs when dry about 10 ounces, and it absorbs approximately five fluid ounces of water. The complete cell contains seven porous blocks and eight metal conductors, and it is said to only weigh when dry 28lb., exclusive of outside containing cell. Among the advantages claimed for this type of storage battery, it is stated that, owing to the construction adopted, there is no possibility of buckling of the plates, no matter how heavy the charge or discharge, and therefore an entire absence of short-circuiting. The absolute control of the active material is provided for by its being shut in so that it cannot be thrown out of its place by expansion or contraction, or by jolting, if used for car service. The cell is flexible, being bound together simply by rubber bands, which allow of expansion and contraction, which occurs during the forming process, or if the cell should heal up owing to a too heavy rate of charge or discharge.

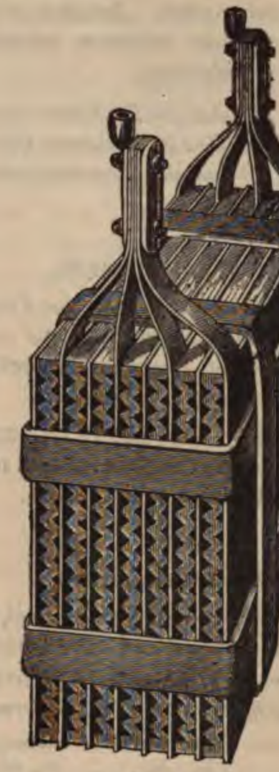

Fig. 13.

The Payen Accumulator.—In preparing his plates, M. Payen makes an intimate mixture of asbestos fibre and fused chloride of lead, and then pours the molten mass into a mould. The material crystallises as it cools, and a chloride of lead plate bound together by the asbestos fibre is the result. The plates are formed in two distinct operations. The chloride of lead is first of all transformed into spongy lead by being made the cathode to an ordinary lead plate as anode. The spongy lead plates are next formed in the ordinary manner, and are then ready to be used. Suitable metallic conductors are either cast or bent round these masses of active material to form both a conductor and a terminal.

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THE POST OFFICE AND THE PUBLIC.

We have long since learnt to doubt the value of the cries of agitators. Of late the Post Office officials, and especially the Postmaster-General, have been attacked because of gentle interference with a private company, which in every direction was trespassing upon the prerogatives of the Post Office. An Englishman never stops to reason when he fancies he has a complaint. His toes have been trodden on and he goes for somebody. The political papers are only too eager to have a chance to damn a political rival, and give any opportunity for charges, true or false, that may be expected to have influence with voters. Was it not Bismarck who said newspapers were the curse of civilisation, and was he far from the truth? Offences that our ancestors would have passed by with a pish, are now made to appear as vital offences against the State and against civilisation. What is the position of the Postmaster-General? He is put into a position of responsibility. He is told that certain Acts of Parliament give to the State certain monopolies. He has to carry on the business of these monopolies so as to please everybody, and not come to the Chancellor of the Exchequer for money, but rather to make the business contribute to the revenue of the country. What would the public and Parliament say if they found a Postmaster-General permitting a private company here and a private company there to infringe the monopoly created by Act of Parliament, and thus take from the revenue of the country to put profit into the pockets of individuals? If such permission was given, the Postmaster-General's tenure of office would be short. He would be kicked out. He would be looked upon as condoning a fraud, and public life would know him no more. That is the Englishman all over. His condemnation for a man who unflinchingly does his duty is just as great, and the only way to prevail with the majority is to hold the candle to the devil. An honest man cannot live in this country; the man who pretends to be honest, and who is all things to all men, is the man who is recognised as the ablest and best of creatures. If this is not so, why the general condemnation of Mr. Raikes for interfering with the boy messengers? This company, in the first place, established an electric call system. If that is not telegraphy pure and simple, we know not what it is. Telegraphy is a Government monopoly, and as such is bound to be protected by Mr. Raikes. Then the call system is supplemented by boy messengers, who carry notes from person to person. This is letter carrying; and letter carrying is a Government monopoly, and as such is bound to be protected by Mr. Raikes. For doing, then, just what he is placed in a certain office to do, the man has been condemned without measure. The silly season of newspapers has been filled up with this nonsense. It was the same when telephony was introduced. The action of the Post Office was anathematised. But the Law Courts held that telephony was telegraphy, and laws are either made to be enforced or not. If not, why the farce of a Parliament to make them? There is no question of a certain service being wanted. If it is wanted and cannot be given because of idiotic laws, change the laws, not blackguard the people appointed to administer the law.

In this particular case we have a double violation of the law, and yet all the argument—if argument it can be called—has been in favour of its continuance. So far as the electrical trades are concerned, it would be in their interests to see electric call systems adopted in every town; and it would be in the interests of technical journals to see the work done by private companies—for our experience of journalism is that outside of politics Government officials bestow no favours. Their translation of *suaviter in modo* is less than bare civility. The technical journals have not even to thank Government offices for advertisements for what may be termed technical materials. Those sops are for the political press, and yet, reasonably or unreasonably, the very people who receive these favours are the very people to condemn any official action whatsoever, whether the action be of the character of doing or leaving undone. This is the position:

1. A company infringes the telegraph monopoly.
2. The same company infringes the letter-carrying monopoly.
3. Mr. Raikes is placed in a position which requires him to prevent such infringement.
4. He prevents such infringement, and
5. Is universally condemned therefor.
6. The whole proves that Englishmen love fair play.

TELEPHONING IN FRENCH.

The London and Paris telephone seems to be destined to have a far less, or, at any rate, a considerably less, usefulness than was at first expected of it, for a very peculiar reason. The telephone can indeed transmit sound, but it cannot enable a person who understands written French to understand spoken French, especially through a telephone. Something, some undefined, intangible difficulty was speedily discovered by persons using the telephone for the first time, and who at first laid their inability to hear to the telephone, but the sound was well defined, and in understanding the mother tongue there is no difficulty. It is only when Englishmen accustomed to correspond or telegraph in French attempt to speak or hear it that the difficulty—one well known to every visitor to foreign lands—comes into play.

Until, therefore, our teaching of French is reformed, which we hope will be soon, or until intending users take lessons in pronunciation, they will evidently have to content themselves with telegraphing as before, or of having an interpreter at the other end who can understand. After all the trouble to obtain an absolute sound-proof chamber for isolating the Stock Exchange men, what a curious result it would be to be forced to employ an intermediary simply because the telephone will not talk the French of Stratford-atte-Bowe!

ELECTRICAL ENGINEERING SYMBOLS.

Prof. Jamieson has favoured us with advance proofs of the part of the new edition of Munro and Jamieson's pocket-book relating to electrical engineering symbols. M. Hospitalier in France and Prof. Jamieson in England have done yeoman service in systematising the symbols in use. No doubt the scheme of Prof. Jamieson will gradually become authoritative. He and his colleague produced the first electrical Molesworth. Their work has stood the test of time, and as edition after edition has been called for, improvements in the shape of additions or emendations have been introduced. The forthcoming edition is to give concrete shape to this scheme of symbols. The method adopted is the natural one, and somewhat similar to that adopted by chemists. The most important word is symbolised by its initial letter, as "L" for "length," "M" for "mass," etc. When two words, such as "ampere" and "acceleration," begin with the same letter, the capital letter is used for the more important and the small lower-case letter for the other, thus "A" for ampere, "a" for acceleration. Prof. Jamieson gives an alternative for ampere in the Greek letter "α." We question the advantage of this, and would prefer one symbol only in each case. One other point is the use of a made symbol to indicate "power in watts, or watts"; and the symbol seems to be the combination of a "W" with "P," only the "P" is not the same kind of letter as the "W"; and the combination, besides not being pretty, would necessitate founders adding another symbol to their types. To symbolise phrases such as "Total turns of magnet wire," inferior letters are used—thus, $I_{a\,w.}$ This is in accordance with recent practice. Pictorial symbols are used to indicate the various machines; but these are of no great importance in connection with letterpress, though they may become classic in illustrations. It would always be preferable to print "continuous-current dynamo" rather than to intersperse the suggested symbol in the letterpress. The latter would require the founder to make these symbols upon particular type bodies, otherwise the printer would have to waste more time in justification than would allow him to pick up the particular letters of the phrase required twice over.

What we have said in connection with this admirable attempt of Prof. Jamieson's is said merely to indicate the one or two weak points, as we see them, in an otherwise fairly complete system of symbols. Similarly, we should suggest Prof. Jamieson's capitals "N" and "S," used for north and south seeking magnet poles respectively, to be in the same kind of type as all the other symbols—in fact, both the initial and the inferior letters might be in the same kind of type. [illegible] his would at once stamp any formula as [illegible]

[illegible] uggestions, the Institution of Electrical Engineers, the Physical Society, and the British Association might formally adopt them, and require contributors of papers to use the symbols. These societies deal more with electrical research than any other, and no doubt if they acted in this way the societies that have merely occasional papers would follow their lead.

PRACTICAL OR MATHEMATICAL.

We are interested to see, from a letter given in another column, that the true part that has been played by "sheer thought"—that is, we suppose, imagination or representation in the concrete as opposed to reasoning by signs—in the discoveries of our greatest inventors is being recognised, and its value both for scientific as well as for commercial progress is becoming acknowledged. The power of arriving at a certain practical conclusion by two apparently different methods—sheer thought or intuition, and mathematical research—is often the result, though we know it not, of very much the same class of mental labour, but in a different direction. The mathematician often uses his imagination and translates his idea, his representation, downwards to signs, though, on the other hand, it is more often that he translates upwards, so to speak, and argues from known to unknown. That this may be also done by sheer thought, and is done by almost every great inventor, tends to show that the power of the human mind in such fields is not yet fully recognised. A curious addition, and, moreover, one of the present day, added to the names of those quoted by our correspondent, will, we are sure, interest our readers; and this is in connection with the huge dynamos at Deptford. We are given to understand, and this on the best authority, that of Mr. Ferranti himself, that the design for these dynamos was made in the phrase adopted by our correspondent—by "sheer thought," and the machine was constructed without any mathematical calculations being made of its output. The results of the similar smaller dynamos were of course well known, and the large dynamos were simply "thought down" upon the paper. The calculations were not made until after the dynamos were constructed, and agreed almost exactly with the results that were actually obtained. We think this instance of mental calculation or representation deserves historic record. We certainly, however, do not advise the ordinary manufacturer to proceed on these lines.

THE ELECTRIC PROPULSION OF AUXILIARY SHIP'S MACHINERY.

The auxiliary machinery necessary in steamships has now become so extensive that the question of its economy enters very seriously into the considerations of shipowners.

The power required to drive the numerous small cylinders of this supplemental plant bears no inconsiderable proportion to the entire steam-raising capacity of the vessel. A slight consideration of the duties to which these engines are devoted will render this point apparent.

There are commonly in use on modern passenger steamers, and among many of those devoted to cargo alone, the whole of the following small machines, and in every steamer there are at least some of them: (1) Donkey feed pumps in constant use, (2) bilge pumps in constant use, (3) fire pumps intermittent, (4) circulating pumps in constant use, (5) air fans in constant use, (6) reversing engines irregular, (7) ash hoists intermittent, (8) winches intermittent, (9) windlass or capstan intermittent, (10) cold-air machinery in regular use, (11) steering gear in regular use, (12) electric light plant many hours in regular use.

These machines are individually driven by small single or double-acting engines, mostly at high speeds, and with very short strokes. The steam supply is taken in many cases from the high-presure boilers which supply the main engines, and the exhaust is frequently coupled to the main condenser; in others it is carried to the open air, and in some instances to both.

It is evident that with such engines no reasonable degree of efficiency can be attained, unless the greatest care be exercised in design and special arrangements be made for reducing the losses in clearance spaces and by condensation. It is, therefore, safe to say that in nine out of ten such engines the waste of steam is very great, and to the known losses must be added those of condensation in the lengthy pipes and connections.

Further, in such of these engines as are provided with a single cylinder only, it is impossible to expand to a useful degree the high-pressure steam now in common use, and such engines habitually discharge their exhaust at a relatively high pressure, unless their supply be withdrawn or reduced in pressure by a reducing valve before admission, in which case the loss is almost equally unfortunate. To such a degree is their wastefulness carried that in certain recent vessels an extra boiler, of same dimensions as the main boilers, has to be added to cover their demands, there being no reliable record of the exact quantity of steam consumed by them.

In cargo vessels recently launched the auxiliary or donkey boiler reaches the dimensions of 11ft. diameter by 10ft. long with, say, 1,000ft. of heating surface, which would suffice to drive, in a regular way, triple engines of 250 h.p. upwards, and propel a vessel of 150ft. length at eight knots an hour. The name of "Steam-eaters" applied by marine engineers to these auxiliary engines, would therefore appear to be well deserved, and when it is remembered that in a vessel of 6,000 tons these engines comprise no less than 60 to 70 cylinders, the inroads made by them in the pockets of shipowners may be estimated. There is then an undoubted opening in this connection for a more economical distribution of power than at present obtains.

Of the various auxiliary engines we have mentioned, there is one which shows superior results in efficiency, and that is the electric lighting machine. It is stated by several high authorities that the combined efficiency of shipboard engines and dynamos is from 80 per cent. to 82 per cent. of the horse-power of steam utilised. This leads naturally to the enquiry whether the power so produced may not be economically distributed on board ship for other duties, and the following considerations seem to point to an affirmative reply.

The known efficiency of combined electric lighting engines and dynamos cited above is obtained in regular practice by engines of very moderate dimensions, under very adverse conditions; and assuming such an increase in proportions as would be required to provide power for other purposes, the economy may be reasonably expected to attain a higher point. Thus a larger plant would no doubt be operated by a triple-expansion engine, thereby affording a far better result in horse-power from the steam used.

The loss in transmission over the necessary leads would not exceed 1 per cent. to 2 per cent. of energy, thereby comparing most favourably with steam transmission, while the saving in pipes and connections, cutting of bulkheads, lagging pipes, overboard connections, etc., may all be carried to the credit side of the cost of an electric installation. The obnoxious feature of heat in various confined parts of the vessel could be obviated, an indirect advantage of no small value, especially in ships of war. The efficiency of the electric motors employed in the actual work of the auxiliary machinery is as high as 90 per cent. of the energy supplied, while they are admirably adapted by their high initial speed to these requirements. It is hardly necessary to add that, with proper mechanical and other arrangements, the motor is as reliable, safe, and lasting as any steam engine.

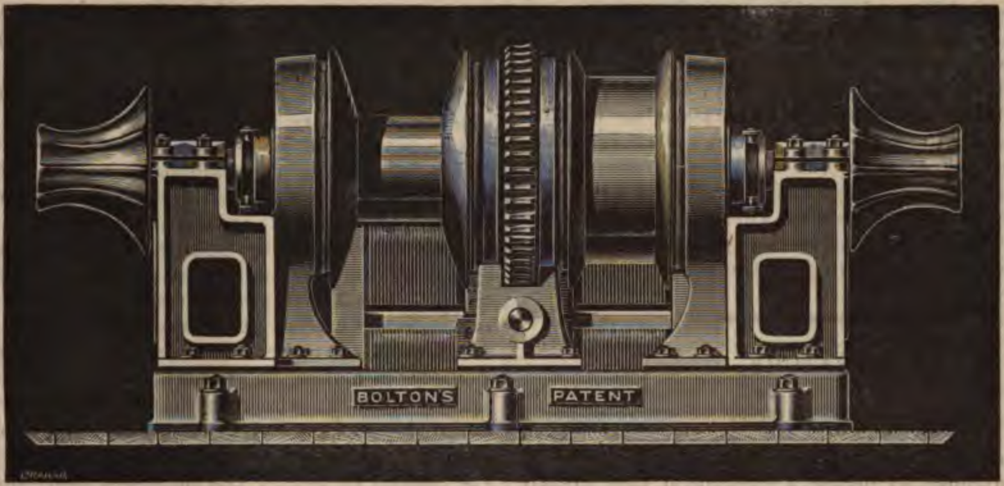


Fig. 1.

The application of electrical propulsion to such duties as are required of fans and pumps, wherein the work is uniform and constant, is a matter within the grasp of any mechanical mind, but the complex and intermittent duties required of hoisting machinery as in the steam winch, afford a serious test of the practicability of the system. In order to make this clear, and at the same time show there need be no apprehension on this point, we cannot do better than describe the electrical ship's winch patented by Mr. Reginald Bolton, C.E., of 110, Leadenhall-street, and of which Messrs. Woodhouse and Rawson are the sole licensed manufacturers.

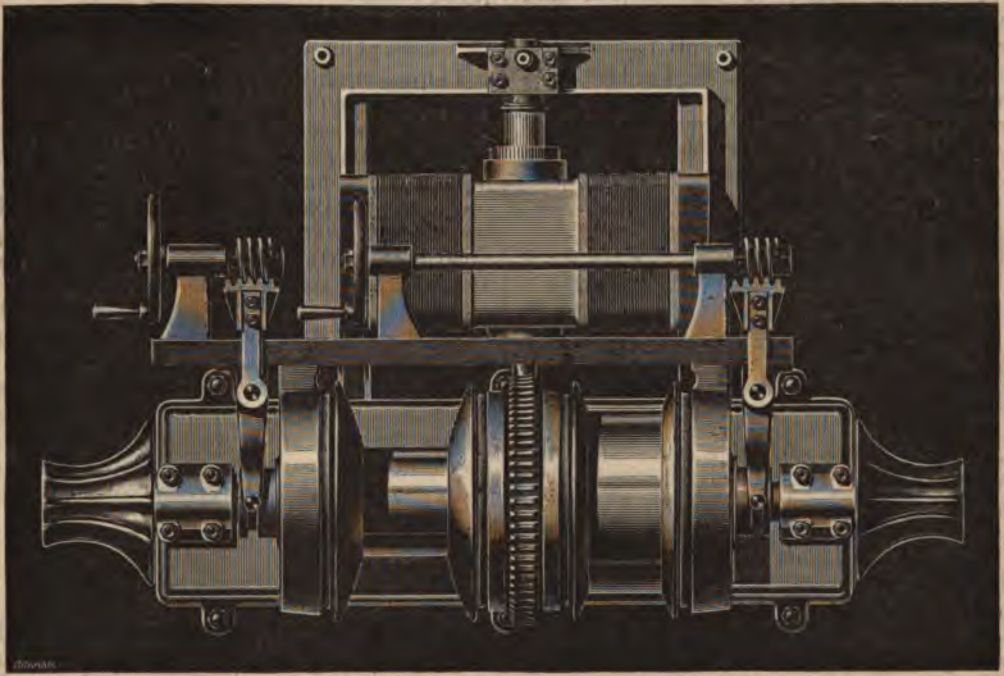


Fig. 2.

This machine, illustrated in Figs. 1 and 2, occupies the same space as an ordinary steamship winch, but possesses the novel feature of lifting variable loads at variable speeds, and of lowering in similar manner. This is accomplished by the use of double barrels, winding both ends of the same rope, operating over two sheaves on the derrick, and raising a single-sheave block and hook which holds the load. These barrels are made of different diameters, so that by winding the two in together the speed of lift is the mean of the two, while by stopping one or the other the speed is made varied in two degrees, and a further refinement may be attained by lowering out the small barrel and hauling in the larger one, while in similar manner the speed of lowering may be varied.

The barrels are driven by large friction cones, in excess of the diameter of the barrels which are connected by hand motion to the driving arm wheel, which is centrally situated on the main shaft. The brake rings are fixtures, and are of equal dimensions to the driving cones. Thus the load is held or raised by motion of the controlling gear in either direction, and it is only by adjustment into the middle position that lowering is effected, and the operator has most absolute and safe control of the load. The warping barrels on the ends of the shaft are of the usual pattern, and, being driven by worm gear, will be held fast when the ship's head is being warped round, and the winch is brought to a standstill by the strain on the cable. This is a crucial test of the electric application of power to a winch, as the stoppage of the motor thereby would mean its destruction, while at same time the cable must be held taut without slipping. The arrangement of a slipping clutch on the worm shaft, however, accomplishes this result, and the motor simply runs on until the excessive strain is relieved. In this winch, then, the above difficult duty is performed, and, in addition, loads can be lifted by single, double, and triple purchase and at corresponding speeds, without any gearing except of the simplest description.

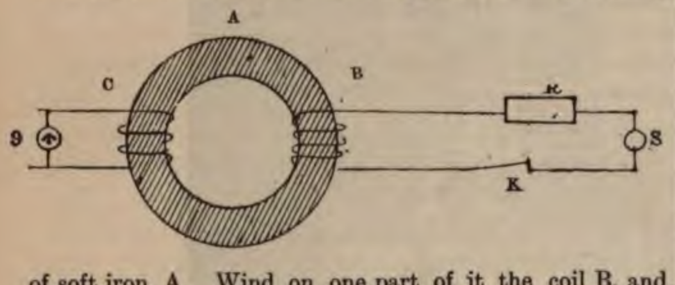
In the finished machine the working gear and motor are strongly cased in, and the proportions of the friction cones are such that no amount of grit, water, or oil can affect their operation. The motor runs continuously in one direction at a uniform speed, and the load can be thrown on so gradually as not to affect its speed appreciably, this being a feature of considerable importance.

The application of this system of lifting gear to electrical cranes of all kinds is likely to be widespread, but does not concern the present subject. Enough has been said to indicate the probability of a wider use of electricity on board ship in the near future, and the lines on which that extension must proceed. Electrical engineers have no finer field for their energies than in the improvement and development of the motor for such purposes as we have dealt with, and, in conjunction with mechanical engineers who are experts in the respective requirements of the various auxiliary engines, they should gradually extend its use in this connection till such an object, a small auxiliary engine with an efficiency of 35 per cent. to 40 per cent., is as much a thing of the past as a haystack boiler.

EXPLANATORY.

LOOPS, LINES, ETC.

The imagination of man is a most wonderful agency. It enables him ofttimes to obtain a convention that greatly assists the understanding of natural phenomena. When Faraday was casting about for some such assistance wherewith to describe magnetic phenomena, he hit upon the term "loops of force," subsequently "lines of force." The latter term has become common, not because it is more appropriate, but because it became fashionable. The gradual increase in number of those who consider electrical and magnetic phenomena from the standpoint of the electric and the magnetic circuit tends towards a reversion to the older term "loops of force" rather than "lines of force." I have been accused of getting mixed on this subject, and to clear the way for other argument will state why I prefer the older term. Mr. Hering rejects "loops" in favour of "lines." Prof. S. P. Thompson and others adopt lines, and talk of lines threading through a given space. Faraday's classical experiment should at once show which term is preferable. Take a ring of soft iron, A. Wind on one part of it the coil B, and upon the opposite part the coil C. Let B be connected to a source, S, and the circuit C be closed through a galvanometer, G. It will be admitted by the opponents of the term "loops," that a current from the source, S, through the coil B, gives rise to "lines" of force almost all of which pass through the iron core, A. They will also admit that these "lines" have some effect on the coil C, as will be shown by the galvanometer, G. Now, my contention is that these so-called lines are complete loops, each forming a closed circuit, the number of loops depending upon the current through B, and the magnetic resistance of the core, A. But the addition of the core, A, to the coil B has an effect in diminishing the current in B, the source S being constant. Adding A is like adding an extra resistance to the circuit of B.



The question now is as to the effect on C. Is it due to cutting lines of force? If so, where and how are they cut? Rather is it not due to the looping of loops of force? A certain number of loops of force "thread through," or, as I prefer to say, "loop" C, and the action on C is proportionate to this number. Increase the number and the action increases proportionately, decrease the number and the action decreases proportionately. There is, however, a limit to the number of loops in A being proportional to the current in B, but up to the point of saturation of A no one will dispute such proportionality.

It may be assumed, then, that everyone agrees:

1. That a current from the source, S, through the coil B, gives rise to a phenomenon which we conventionally describe as due to lines or loops of force through A;
2. That these lines or loops of force going through A, and thus through the coil C, give rise to a current in C which is shown by the galvanometer, G;
3. The current in C is proportional to the number of lines or loops in A.

When the gentleman whose criticism has called forth this explanation shows that it is preferable to use the term "lines cut" rather than "loops threaded," or looped in this and other simple experiments, it will be time enough to determine which of us is "mixed" in his ideas.

The resistance, R, in the diagram refers to a further experiment with the apparatus, which may now be explained, and, if admitted to be correct, will form one of the proofs that maximum current is a summation, and does not necessarily occur at the point where the loops of force are densest. R represents a resistance of considerable value. For ease in making the experiment I used a sliding resistance, so that the whole resistance, or any part of it, could be quickly and continuously put into or taken out of the circuit. A contact key can be inserted at K.

Let contact be broken, and the whole resistance, R, be in the circuit.

Make contact.

If R is large enough there will be little or no deflection of the needle of G—that is, there will be little current through B, few loops through A, and little current in C.

Keep contact made.

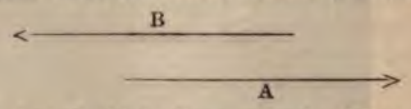
Take out resistance, R, as rapidly as possible. The galvanometer needle will make one swing to its maximum point, provided it be a fairly dead-beat instrument.

Break contact.

Make contact, again with R out. The needle swings to the same point as before.

I interpret this experiment to mean, that a continuous rapid decrease of resistance, R, leads to a continuous increase of current through B, a continuous increase of loops of force through A, and a continuous increase of current in C, the maximum current in C being reached as the last resistance is taken out of the circuit B. The maximum current in C, when R is rapidly taken out, is practically the same as the current in C when contact is made with R out at the time of making contact.

Another experiment, quite as simple, and conveying a moral, may be described, though probably my interpretation may be criticised. Let A represent a portion of a circuit, with current in direction shown by the arrow. Let B represent a part of another circuit. When B is brought within the field of A, a current flows in B, opposite in direction to the current in A. Suppose the current in A to be constant then the reverse current in B is momentary.



Upon these facts I think all are agreed. What causes the current in B? Upon this point, also, agreement is pretty general. It is due to the action of the whirls, or the lines or loops of force around A, commonly called the field of A. The important point to which I wish to direct attention in this experiment is that though the current in B is momentary, the action of the field of A upon B is continuous. My interpretation up to this point is that the influence of the field of A is to *decrease* the electric pressure in that portion of B upon which it acts. This decrease of pressure at the point B leads to a readjustment of the pressure throughout B, the momentary current producing, as it were, an equal and opposite action to the action caused by the loops of force of A. That these two forces are acting and neutralising each other, so long as the current in A is constant, is evident from the fact, upon which all are agreed, that if the current in A ceases, the original momentary reverse current in B gives place to a momentary current in B, now in the same direction as that just ceasing in A. It matters not whether the explanation be that the original field continued to act, or whether the loops of force were broken down and continually replaced with immense rapidity by the constant current in A. Whatever the real explanation, the fact remains that on causing the current in A, or bringing the circuit B within the influence of A, there is action of A upon B, and this action influences B so long as the current in A continues. My point is this, that although the current in B is but momentary, the loops of force of A, to which this current is primarily due, do not cease to act, or that their successors do not cease to act, but that so long as the current in A is constant, there are, from the time of the momentary current in B, two equal and opposite forces acting in B. This I claim to be proved, because any fluctuation in the current in A is met with a corresponding fluctuation in the condition of B. That is, so long as the loops of force due to A are around B, they act upon B.

This experiment can be taken a step further. The current in B, as measured by a galvanometer, is proportional to the number of loops of force around the conductor. This can be shown in two ways:

1. By increasing the length of B acted upon.
2. By increasing the density of the loops around B in a given space.

The latter is perhaps the simpler method. Doubling the current in A, thus doubling the strength of field, or doubling the density of loops, causes double momentary current in B. If this be done by decreasing the resistance of A continuously with sufficient rapidity, the current in B will increase in proportion to the decrease of resistance in A, or in proportion to the increase of loops of force due to A. There is no discontinuity in the swing of the galvanometer needle indicating current in B; hence I say that the total current in B is that due to the total number of loops of force around B. In other words, when the looping of lines around B is rapidly continuous, the effect of the first loops is not lost before the effect of the last loops is impressed, and the total effect or the maximum current is the summation effect produced by all the lines so looped.

So many friends have, by pen or word, tried to convince me that I am wrong in what I never said or intended to say, but which I am wrongly stated to have said, that I am obliged to enter somewhat fully into what I have really endeavoured to say. Any friends who will try the experiments mentioned, and send the results of their investigations, will have my warmest thanks. I am open to conviction, but hitherto those who have tried the experiments have come to the same conclusions as myself, while some who have not tried the experiments are ready with other interpretations, and are quite convinced I am wrong in all my conclusions. I ought to state that I have not attempted to find out the rate at which loops must be added to give the summation effect, but have manipulated the apparatus as quickly as I could revolve a contact-piece through 360deg. C. H. W. B.

(To be continued.)

CORRESPONDENCE.

ALTERNATE-CURRENT MOTORS.

SIR,—In your issue of March 6 I find the passage: "Mr. Kapp described the position as it exists. He showed how Ferraris first of all pointed out the right way to get an alternating-current motor that was self-starting, and how Tesla and others had worked in the direction indicated by Ferraris," etc.

I would be very glad to learn how Mr. Kapp succeeded in showing this. I may call his attention to the fact that the date of filing of my American patent anticipates the publication of the results of Prof. Ferraris in Italy by something like six months. The date of filing of my application is, therefore, the first public record of the invention. Considering this fact, it seems to me that it would be desirable that Mr. Kapp should modify his statement.—Yours, etc. NIKOLA TESLA.

New York, 17th March, 1891.

UNDERGROUND CABLES.

SIR,—I notice with some interest a short paragraph in your last issue with regard to the testing and the specifications of cables for electric light use. The point therein mentioned is exceedingly important, and I am glad you have drawn attention to it.

With the underground electric light circuits extending in all directions, it is very necessary for those who have to watch the interests of the public to be able to test and specify with a considerable degree of accuracy the insulation of an underground cable; not as it is, in coming from the makers' hands, but as it will be in a few weeks or months under a steady strain, day and night, of a known pressure.

I think, therefore, that a tentative model test and specification might reasonably be looked for by those who, like myself, do not pretend to know all the details, from electrical engineers or the Institution to which they belong, and I trust the suggestion will be taken up in the proper quarters.

While writing to you upon this question I should like to also add that the subject of how much leakage in parallel systems at low tension, say in amperes or decimals of an ampere, per thousand lamps connected should be regarded as a maximum is also important, and will certainly tend to become more so in large town installations.

If this letter serves to draw replies from those who are competent to advise I shall be very pleased.—I enclose my card, and beg to sign myself A BOROUGH ENGINEER.

CONCENTRIC MAINS.

SIR,—It was very amusing to see, last week, Mr. J. D. F. Andrews let off his surprise at your note on the new concentric house wires, formed of two copper tubes one inside the other. "It should have been brought out many years ago," says Mr. Andrews, "as it is quite eight years since I commenced working at such a system." Now I have no reason to go against Mr. Andrews, or to hold a brief for the unknown inventor of the double copper tube distribution. But I do not see that because Mr. Andrews was working eight years ago on "such a system"—presumably the earlier forms of his present concentric cable—another inventor may not claim novelty for what certainly is a novel and bold idea—the use of bare conductors one inside the other. If there is any possibility of seeing and testing this system, many electrical contractors would like to avail themselves of it, and possibly compare it with that of Mr. Andrews's. The system seems cheap, easy, and practically everlasting. The questions are, is it safe, and will it be allowed by companies and fire offices?—Yours, etc., G. P. O.

SHEER THOUGHT.

SIR,—In a note which you reprint from the *Globe* in your last issue, reference is made to the work of S. Tolver Preston—a work which I read at the time it appeared, and have dipped into it many times since with great interest. I agree with the writer of the note that Mr. Preston is a physicist rather than a mathematician, and have thought it might be instructive to know what mathematicians have done in developing any application of science. From my childhood I have had it dinned into my ears that everything is open to the mathematician, but, as a man of the world, I have been unable to find that they have benefited the human race to any great extent. Was Trevethick, or Newcomen, or Watt, or Stephenson a mathematician? These men made steam engineering. Were Gramme, Brush, Maxim, Edison, Crompton, Mordey, or Esson mathematicians? Yet, with Kapp and Hopkinson (who may perhaps be termed mathematicians), these are the men who have made electrical engineering. The greatest architects and the greatest engineers have not been mathematicians, and if we could sum up the benefits conferred by Trevethick and his successors, by Gramme and his successors, by the architects, engineers, and chemists, it would be found that "sheer thought" stands triumphant, and mathematics are out of the running in the race for progress. Good luck to such men as S. T. Preston.—Yours, etc ,

A MAN OF THE WORLD.

CRYSTAL PALACE EXHIBITION.

SIR,—Referring to your note under this heading in last week's *Electrical Engineer*, when at the Palace the other day I saw the identical Galloway engine which was used at the 1881-2 exhibition to drive the Gulcher Company's dynamos, and still is employed in that work. I was told by the driver that it has run almost without a hitch during the 10 years that have intervened. Not a bad performance.—Yours, etc.,

W. H. NEW.

Dulwich, March 30, 1891.

AYRTON AND PERRY INSTRUMENTS.

We illustrate herewith some new forms of the well known Ayrton and Perry electrical measuring instruments, made by the Acme Electric Works. The new magnifying spring voltmeters and ammeters are now made combined in one instrument in several sizes. There are two scales on one dial with only one pointer for both, and one terminal common to both circuits, three terminals only being required; that not in use is covered by an ebonite cap, as shown. Special precautions are taken to ensure good insulation, and the indications are all guaranteed correct to within 1 per cent. They are contained in well-made teak or oak cases, and are designed to meet the desire for a portable combined measuring instrument often expressed by many electrical engineers.

The new twisted strip ampere and voltmeters, which have been designed by Profs. Ayrton and Perry to replace the old hot-wire instruments, are adapted for use with small E.M.F.'s and currents, and calibrated to read in 100ths of volts and amperes, and the indications are correct to within ½ per cent. They are arranged for use either vertically or horizontally.

INDUCTIVE DISTURBANCES IN TELEPHONE CIRCUITS.[*]

BY J. J. CARTY.

It was not known until 1838 that the earth might be used instead of a return wire in the circuit of a telegraph line. This fact was discovered by Steinheil, while making experiments to determine whether the track of a railroad could be used to complete the circuit instead of a return wire. Steinheil's discovery has been considered as one of the most important in the art of telegraphy, and since his time it has been the almost universal practice to use the earth as a return in telegraph circuits. When, however, the earth return is used with the telephone, it is found that owing to the extreme sensitiveness of that instrument, many foreign currents, which would produce but little effect on telegraph instruments, become a source of serious trouble. For this reason, in telephony it is often necessary to use a complete metallic circuit. Thus it has come to pass that a return to the original practice of employing metallic circuits, as in the case of the crudest telegraph instruments, is now regarded as a most important improvement in connection with that most highly developed of telegraph instruments, the telephone.

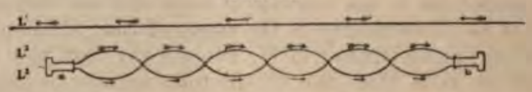
To obtain complete freedom from inductive disturbances in the telephone, it is necessary not only to use a metallic circuit, but to place the two wires composing the circuit in a special relation to the source of disturbance. One of the methods of so arranging the wires is shown in Fig. 1.

In this case the two sides of the circuit L^2 and L^3 are twisted spirally about each other, so that their average distance from the disturbing wire, L^1, shall be the same. With such a plan, the telephones *a* and *b* are not affected by induction from the wire L^1. This fact has usually been explained by assuming that a current commencing to flow in L^1 tends to induce two currents in the opposite direction to itself, one in the wire L^2, and the other in the wire L^3; that both currents are of the same strength because the average distance of L^2 and L^3 from the disturbing wire, L^1, is the same, and that the telephones *a* and *b* are silent because they are acted upon by two equal and opposite forces. The above theory seems at first sight to be correct.

I have made a number of experiments which seem to prove that in the case described the inductive action, instead of tending to produce a simple current in each side of the metallic circuit, actually does produce a number of different currents in each wire and in both directions.

In Fig. 2, L^2 and L^3 are two well-insulated copper wires, 500ft. long and 3ft. apart. These wires are joined together at each end through an ordinary telephone. L^1 is a well-insulated wire similar to the other two and placed within ½in. of L^2. At one end of L^1 is placed a Blake transmitter, T, and at the other end is placed a subscriber's bell, S; L^1 being grounded at both ends as shown. When the transmitter, T, is operated, either by speaking into it or by vibrating a powerful tuning fork in front of it, disturbances are produced at the end telephones.

FIG. 1.



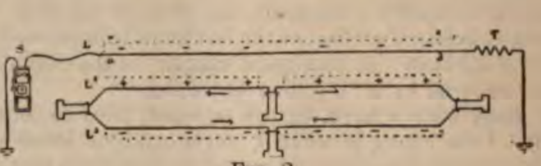


FIG. 2.

If telephones are inserted at the centre of L^2 and L^3, it is found that at those points no sound is heard, while the noise of the end telephones continues as before. This constitutes a simple case of inductive disturbance, and can only be explained by assuming that the wire L^1 acts electrostatically upon the circuit composed of L^2 and L^3, or, in other words, that we are dealing with a system of condensers in series, of which L^1 constitutes one plate, the earth another, and the wires L^2 and L^3 two intermediate plates which are joined together through the end telephones.

Let us assume that at a given instant the height of potential along the wire L^1 is represented by the lines, *a b* and *c d*, and the charge upon L^1 by the rectangle, *a b c d*. The presence of this charge, which, we will say, is of the minus sign, is accompanied by an equal but plus charge on L^2. This produces a minus charge on the wire L^3, which in turn acts upon the earth. Now, we will assume that the potential on L^1 is reduced to zero. This causes a restoration of the equilibrium in the circuit composed of L^2 and L^3, which is accompanied by a set of currents as represented by the arrows. The plus charge on L^2, flowing through the end telephones, neutralises the minus charge on L^3, thus leaving a neutral point at the centre of each of the wires L^2 and L^3.

In this and the succeeding experiments the induced charges are represented by rectangles. This is not a strictly accurate method, but as an error in this respect only affects the result quantitatively, and cannot alter the conclusions, I have adopted it on account of the simplicity of treatment which it permits.

The potential along the wire L^1 at a given instant is represented as being constant, as it is found that, owing to the high impedance in the instruments, there is practically no fall of potential in the wire itself. Furthermore, it was found in the experiments about to be described that the results were the same whether the disturbing wire was open or connected to earth through the bell, S. There would be a fall of potential along the wire L^1 if it were of such a length as often found in practice, and the distribution of the charge would be modified accordingly. But as this fact would only affect the location of the neutral points, the question of the fall of potential will not be taken into consideration, and the disturbing wire will be shown open at one end.

Fig. 3 shows the same circuits as used in the previous experiment, except that the wires L^2 and L^3 are caused to change places at their centres, but are continued in the same plane, as in Fig. 2. This is what is called a "transposition." The telephones at the ends and in the middle are retained as before. Under these conditions, when the transmitter is operated, a diminished sound is heard at a and b, and x and y, instead of being silent as in the first case, now emit a sound of the same intensity as a and b. When telephones are placed at the quarters, l, m, n, o, the sounds at $a\,b$ and $x\,y$ continue as before, but nothing is heard at l, m, n, o. The effect of this one transposition has been to reduce the disturbance at the end telephones, a and b, and to cause a shifting of the neutral points from the centres to the quarters, and an increase of their number from two to four.

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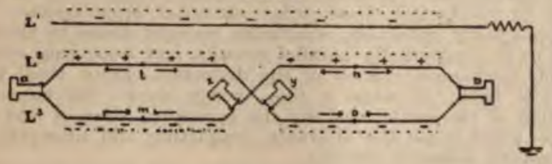
[*] Paper read at the fifty-fifth meeting of the American Institute of Electrical Engineers, New York, March 17, 1891.

An examination of the induced charge show how these results have been brought about. It will be seen by reference to Fig. 3 that there is on the first half of L^2 a positive charge, and on the second half a negative charge, and on the first half of L^3 a negative charge, and on the second half a positive charge. When the positive charge on L^2 discharges, half of it goes through the telephone a, and half through the telephone y. The positive charge on L^3 escapes in a similar manner, half going through telephone x, and half through telephone b. This produces four currents, two starting from point l and two starting from the point n. One of the currents from l meets a current at o, coming from the point n, and one of the currents starting at the point n meets a current at m, which started from l. The currents flowing through the end telephones in this case are not so strong as when no transposition is employed, because they are due to an induced charge which is represented by an area half as great. It is found that as the number of transpositions is increased the number of neutral points is also increased, and that the area representing the charge which escapes through the end telephones is reduced. To obtain silence, therefore, it is necessary to increase the frequency of transpositions until the discharge through the end telephones is so small as not to produce sounds therein. Fig. 4 shows a circuit containing three transpositions, one at the centre and one half way between the centre and each end. In this case, if we could neglect the resistance of the telephones, the current going through the ends would be reduced to one-fourth of its original proportions, and eight neutral points would be produced, one in each wire at the centre of each transposition.

FIG. 3.



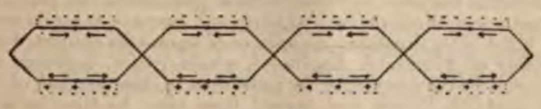


FIG. 4.

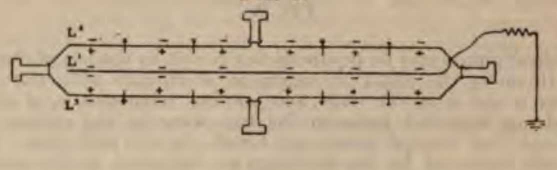
In practice the impedance of the telephones must be taken into consideration, so that if, in Fig. 3, the middle telephones x and y were omitted, the neutral points would be found to move towards the ends, and the currents flowing through the end telephones would be correspondingly reduced.

According to this theory of transpositions, if the instruments and distances between wires on a given circuit remain constant for a given period of alternations in the disturbing wire, the number of transpositions necessary to obtain silence will depend on the E.M.F. of the disturbing wire, and the specific inductive capacity of the dielectric. An increase in the value of either of these factors will, if silence is to be maintained, require additional transpositions, their number depending upon the value of the change which is made.

Where the disturbing wire is placed at an equal distance from both sides of a metallic circuit, no noise is produced in telephones located in that circuit, and a balance once being obtained, it is independent of both the E.M.F. of the disturbing wire and the specific inductive capacity of the dielectric. Fig. 5 shows such an arrangement of circuits—L^2 and L^3 are the two wires composing the metallic circuit placed the same distance apart as before, and the disturbing wire is at an equal distance from both. When the disturbing wire is in operation, no sound is heard at the end telephones, or at telephones located at the centres. This may be accounted for by assuming that at a given instant a negative charge is on the disturbing wire, which produces a positive charge on the inside of L^2 and L^3 and a negative charge on the outside of those wires; and that when the charge is removed from the disturbing wire, a set of currents is set up in the wires L^2 and L^3 in a direction at right angles to their axes, as shown by the arrows. In this case the flow is lateral, and no current passes through the end telephones or through telephones located at the centres. It will thus be seen that this method of arranging wires differs essentially in its action from the plan of using transpositions. Unfortunately, however, its practical application is limited to two circuits.

Where the disturbing wire occupies the position shown in Fig. 5, the flow in the conductors is lateral only when the wires L^2 and L^3 are insulated from the earth. If a ground be attached to the centre of L^3, as shown in Fig. 6, the flow of current becomes longitudinal, and the telephones a and b are found to be effected by loud disturbances, while the telephone x, at the centre of L^2, is found to be silent. This is because the disturbing wire, which we will say is negatively charged, induces a positive charge upon L^2 and L^3 and a negative charge upon the earth. The discharge in this case is effected by two currents starting from x, which thus becomes a neutral point, and passing through the end telephones to the ground as shown by the arrows. If the ground be removed from the point y toward the telephone a, the neutral point will be found to move toward telephone b, and if the ground be put at the centre of resistance of the telephone a, the neutral point will be found to be at the centre of the telephone b. This is well illustrated in Fig. 7, where a and b are telephones of special construction, admitting of the attachment of grounding keys, K^1 and K^2, at their respective centres. In this instance, when the disturbing wire is in operation and both keys open, no sound is heard at any of the telephones, the flow of current being lateral. If the key K^1 be closed, sound is immediately heard at telephones x and y located at the centres of L^2 and L^3, but the telephones a and b are still silent. This is because the charge and discharge take place along the conductors L^2 and L^3 to and from the earth at K^1, thus passing through x and y, a being silent because the currents go through it differentially, and b is silent because it is located at a neutral point. To prove that current flows through telephone a, another telephone may be inserted in the ground branch at K^1, and it will be found to be loudly affected. If both keys, K^1 and K^2, are closed, silence is again obtained in the four telephones a, b, x, y. In this case the charge and discharge from the wires L^2 and L^3 divide at the centre and flow back and forth at both ends, x and y being silent because they are at neutral points, and a and b are not affected by the currents which flow through them, because of the differential action referred to.

FIG. 5.



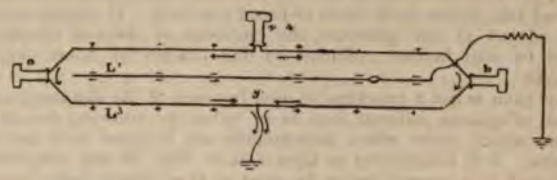


FIG. 6.

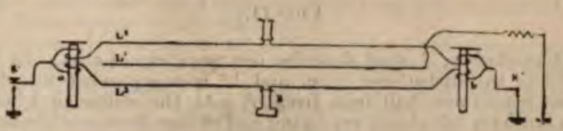


FIG. 7.

Two systems have now been described, one in which the induced current is lateral, and the other in which it is longitudinal. I think it follows from the foregoing experiments, that where wires are twisted about each other, as shown in Fig. 1, both of these actions are combined. At the left hand of Fig. 8 a cross-section of the three wires L^1, L^2, and L^3, Fig. 1, is shown. In this position the wires occupy a place with reference to each other exactly as in Fig. 2, and the tendency of the disturbing wire is to cause a longitudinal flow in L^2 and L^3. If repeated cross-sections of these wires are made, a point will be reached at which the three wires are disposed as shown at the right hand of Fig. 8,

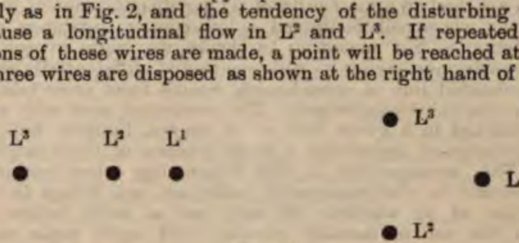


FIG. 8.

where it is seen that the disturbing wire, L^1, is at an equal distance from L^2 and L^3, and the tendency is to produce a lateral flow. The actual currents produced must be the resultant of these two actions.

Fig. 9 shows a plan quite different in principle from anything heretofore employed. It is of interest not so much on account of any practical application which it may have at present, but because it is a very striking proof of the electrostatic nature of inductive cross-talk between telephone circuits. L^1, L^2, and L^3 are the same wires as used in the previous cases, L^1 being half an inch from L^2, with the addition of an extra wire, L^4, placed half an inch from L^2 and joined by a conductor, w, with the disturbing wire, L^1. L^2 and L^3 are 3ft. apart. When in this condition the transmitter is operated, no disturbance whatever is heard in the end telephones; if the wire w be disconnected, the usual noise is heard, but is found to disappear as often as L^1 and L^4 are joined together. This action is explained by the fact that L^4 is at the same potential as L^1, on account of being joined to it by the wire *w*, and acts with the same force on L^3 that L^1 does on L^2. The flow in this case is lateral, as indicated by the arrows; and the telephones are silent.

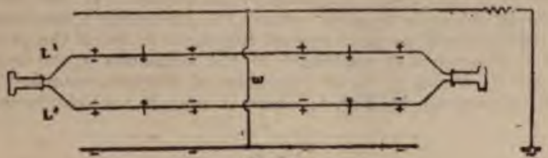
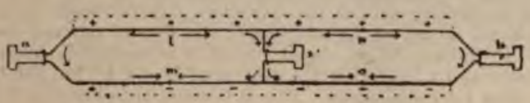


Fig. 9.

Neutral points may be produced in a circuit by the use of shunts. Fig. 10 shows the usual arrangement of circuits with the telephones *a* and *b* at the ends, and another telephone, *x*, of equal impedance branched between the two wires at the centre. In this case four neutral points are found—two in each wire. The currents produced by the discharge are indicated by the arrows. Thus, by the addition of one shunt, the disturbing currents in the end telephones have been reduced one-half. If similar shunts were placed at the quarters, the currents at the end telephones would be still further reduced to one-quarter of their original strength.

This plan is not a practicable one, because of its shunting effect on the telephone current, but is of value as showing one of the actions which occur when instruments are bridged into metallic circuits. It is interesting to note that in Fig. 10 the telephone *x* is affected by a current twice as great as that which flows through either of the end telephones.

Fig. 10.



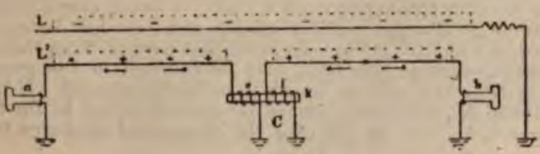


Fig. 11.

Before closing, I shall describe one more experiment. In Fig. 11, L^1 is the disturbing wire, and L^2 is a grounded telephone circuit placed one half inch from L^1. At the centre of L^2 there is an ordinary telephone repeating coil or transformer, C, containing two windings, *e* and *f*, of copper wire, each having a resistance of 160 ohms. One end of each winding is grounded, and the other end is connected to the line as shown. Assuming that the impedance of each telephone is equal to that of each coil of the transformer, a neutral point will be found at the centre of each half of L^2, and the disturbing currents flowing through the end telephones will be only half as strong as though the transformer were omitted. If now the connections of the transformer be reversed so that the discharges from the two sections of line pass through it in opposite directions, no magnetism will be produced in the core, *k*, and consequently the transformer coils offer an easier path to the discharge. This causes the neutral points to move toward the end telephones, and consequently reduces the disturbance still further.

I have not had an opportunity of trying this experiment with a transformer whose coils contained a low copper resistance and a high inductance, but according to theory we might expect that such a transformer having its coils connected differentially should free a grounded line of considerable length from cross-talk and other electrostatic disturbances. The number of such coils which can be worked in a given line is, of course, limited, but with properly-designed apparatus a large number of them might be used. This arrangement is also interesting when considered with reference to electromagnetic induction, and brings to mind a question as to whether we may not at some future time abandon the use of metallic circuits, and again make use of Steinheil's discovery.

Supplementary Note, Communicated to the Secretary by Thomas D. Lockwood.

I understand that Mr. Carty's paper is to be read this month. If in that understanding I am correct, I regret exceedingly that it is not in my power to be present with you in a tangible form. It is, moreover, difficult to make a written communication upon a topic which as yet is unannounced, but as I have some reason to believe that Mr. Carty will speak upon the subject which he has largely made his own, I will have the temerity to hazard a word or two.

If Mr. Carty continues to hold the views of two years back, I understand him to believe that electrostatic in contradistinction to electromagnetic induction is chargeable with the major amount of discredit as an agency in disturbances on telephone lines; or at any rate, that it is a much more important agent in the development of such disturbance, whether noise or cross-talk, than has been supposed.

From long experience and observation it appears to me that the several agencies in causing disturbing phenomena in telephone circuits which manifest themselves in the telephone receiver preponderate largely in accordance with the conditions of the circuit; that the environment (to use the language of social science) of a telephone circuit has a good deal to do with its behaviour. Thus a line which has considerable leakage uniformly distributed throughout its length will suffer very little from electrostatic induction either manifested as a disturbance or as a retarding agency, not because the electrostatic induction is not exercised or is not present (or, to put in a more modern, and, I think, a more correct phraseology), not because inductive circuits are not formed, but because there being by virtue of the leakage or poor insulation an opportunity for a number of short cuts or cross conductive circuits. These are utilised for the conduction of the electricity, permitting the establishment of equilibrium or discharge at the expense of the utilisation of the inductive circuits which tend to retain charge. The phenomena exhibited is comparable to a gallon vessel, say, in which liquid may be poured, but which has a number of holes bored through its sides. The vessel has a capacity of one gallon, but, being leaky, does not hold its charge, and the said charge is dissipated as quickly as it is formed. In this case leakage tends, if accentuated, to become the chief adverse agency, as not only does a leaky circuit dissipate induced charges quickly, but it also permits stray currents which may disturb to come on the lines from external points.

As a matter of fact, the several disturbances upon telephone lines are due to a large variety of causes. It is customary to say that the telephone is an extremely sensitive electroscope, or galvanoscope; and that it will take cognisance of almost infinitely small currents. This statement, however, should be made with some reservation.

The more correct statement is, of course, that the telephone is a sensitive indicator of changes in electrical currents.

A current may be caused to circulate through its helices which is sufficiently strong to make them warm, but if that current be steady, it will not be able to produce a sound in the telephone. Telephone disturbances then, broadly stated, can result only from changes which occur in the electric condition of the circuit within which the telephone is included, and these changes may be produced by conduction from other electrical organisations; by electromagnetic induction, sometimes brought about by changes going on in substantially parallel circuits, and sometimes caused by the mechanical motion of the disturbed circuit itself in a magnetic field; as when a line swings across the magnetic meridian of the earth; and by the successive charges and discharges which cause the alternate completing and disrupting of electrostatic inductive circuits.

If we exhaustively examine the literature of the subject we shall find that the idea that electrostatic phenomena are concerned in disturbances of telephone and telegraph circuits, is by no means new. Mr. Culley presented a paper once upon this subject, before the Society of Telegraph Engineers, which paper, together with a most instructive discussion, is published in the journal of that society, and Mr. Preece and myself from time to time have also repeatedly referred to it. It is due, however, to Mr. Carty to say that his considerations and researches in this line show him to be an original and independent thinker and observer, and that I have found his work to be instructive in the highest degree.

I think, while he is undoubtedly right in attributing a large share of inductive disturbance in telephone lines, that he does not give sufficient weight to the equally undoubted fact that electromagnetic induction is also an important factor, and that, as I have already pointed out, the conditions of any individual circuit largely govern its action. An interposed plate or an envelope of metal between the disturbed and disturbing circuits will, if sufficiently thick, and if united to earth, screen so much of the induction as is electrostatic in its origin, but it will not screen electromagnetic induction, and thus whenever it is worth while the sources of inductive disturbances can be analysed. And while the inductively neutral metallic circuit—the circuit with two wires closely adjacent and twisted together—is indeed a specific against electromagnetic inductive disturbance, it also tends to increase the retarding effect of electrostatic induction exercised between the two wires of the circuit.

Some of the considerations which tend to delay the universal employment of metallic circuits in telephony are, however, that there are an immense number of wires even when but one is used to a circuit; that twice the number of wires means twice the number to get out of order, to cross, break and leak, and consequently twice the number to take care of, and handle.

I hardly think that sufficient thought is given to these matters by many who talk glibly about the necessity and essentiality of using metallic circuits only, for all classes of telephone work.

In conclusion I wish to suggest, that inasmuch as the telephone only notes electrical changes, we cannot accurately say that sound can be produced in it by electrostatic charge.

It is the fact that it is the motion caused in the act of forming and dissipating charge that produces the disturbing sound. But a charge in the act of formation or dissipation is practically a current; and as a current in the act of change, it necessarily varies also the magnetic field constituted by the circuit within which it is circulating; and as a further consequence therefore sets up in an adjacent and disturbed circuit electromagnetic induction currents. Thus the disturbing action is a compound one; operating first by the successive inductive charges and discharges induced in the disturbed circuit, by the changes occurring in the disturbing circuit; and secondly, by electromagnetically induced currents developed in the disturbed circuit by changes in the magnetic field constituted by the disturbing circuit.

ELECTRICITY IN RELATION TO THE HUMAN BODY, ITS DANGERS AND ITS USES.*

BY H. NEWMAN LAWRENCE, M.I.E.E., AND ARTHUR HARRIES, M.D., A.I.E.E.

(*Concluded from page 326.*)

The next part of our paper deals with the uses of electricity in disease. Such uses are numerous, valuable, and steadily on the increase. Without trespassing upon the distinctly medical aspect of the subject, we may refer to those well known, but little understood, effects of electricity upon the nerves and muscles of the body, by means of which many diseases depending upon nerve derangement may be ameliorated or even cured. Speaking generally, continuous currents, properly applied, tend to promote disintegration and nutrition, while alternating currents act as local stimulants. But in this connection it is most necessary to bear in mind that it is only by accurate measurement of the currents used, and by careful attention to the electro-physiological or electro-chemical changes it is desired to bring about, that satisfactory results can be obtained. Electricity is capable of doing much good to the body under numerous conditions, but that it is also capable of doing much harm we have already shown. Extreme care, therefore, is necessary in making electrical applications to the body. Care in diagnosis, so that a definite idea may be obtained as to what it is the electricity is to be directed against; care in the selection of that form of current best suited to do the work required to be done; care in choosing the position of the electrodes and the direction of the current; and, lastly, care in measuring the dose precisely, both as regards current, strength, and time. For an electrician who is not also a medical man, to prescribe electricity is utterly wrong. For a medical man who is not also an electrician, to administer electricity is equally wrong. For one who is ignorant of both electricity and medicine, to prescribe or administer an agent so powerful for good and evil is (or at least should be) criminal. The mysteriousness of electricity, and its subtle methods of action, render it peculiarly adapted to the purposes of the quack and the charlatan, while the indifference, suspicion, and conservatism of the medical profession, as a body, has hindered to an enormous extent the study and development of the uses of this valuable curative agent. The public have thus been thrown into the hands of men who, for the most part, know absolutely nothing either of electricity or of the diseases they profess to cure. Still, truth must prevail; and we are convinced that, however great the value of electricity in disease may be now, its possibilities in the near future are far greater.

With the methods of electrical treatment this paper has nothing to do, but there is one use of electricity in disease not indicated above which is new as regards its practicability, and which, moreover, opens up a field of usefulness little expected a short time back. We refer to "cataphoric medication," or the process of passing drugs in solution through the skin by means of the cataphoric power of continuous electric currents.

Experiments have been made both in Germany and America within the last few years by which evidence, more or less uncertain, had been obtained of the power of electric currents to carry drugs in solution with them through the skin; but, as far as our information goes, nothing reliable had been arrived at, and some of the experimenters were even uncertain as to which pole should carry the solution to the body.

In the early autumn of 1889 we conducted a series of experiments in this department of work, and found the results so promising that we at once proceeded to use it as a method of treatment. We have been much gratified with the results of its application in many cases of actual disease. From the reports of the International Medical Congress at Berlin in 1890, we find that subsequent to our adoption of this method in practice, Mr. Edison, of New York, has been making experiments in the same direction.

We will here illustrate the methods by some experiments.

[**Dr. Harries**: The experiment to be performed upon the living subject will be to anæsthetise a portion of the arm by the electrical application of a solution of cocaine, and afterwards to pierce the skin with a sharp needle several times to electrolyse the roots of hairs, and extract these hairs without the patient feeling the least pain. The fundamental experiments upon which the process of electrical transmission of drugs, which we have termed "cataphoric medication," are as follows: Two beakers are filled to an equal level with two different liquids—in one a dilute solution of sulphuric acid, in the other a solution of barium chloride. The two are connected across by a piece of wick soaked in sulphate of barium. To determine whether diffusion took place mechanically or by capillary attraction, these were left for 24 hours, but no transmission could be detected. The constituents were so chosen that there could not be the ordinary electrolytic action by the breaking up and recombination of chemical molecules. On inserting the two plates—carbon or platinum—into the beakers, and connecting them with the positive and negative poles of a battery, and passing 100 milliamperes of current from the sulphuric acid to the barium chloride, within a few minutes a slight cloudy appearance is seen, quite distinct from the bubbles of hydrogen that arise on the plate, and, though at first requiring a magnifying glass to distinguish, in the course of about half an hour it is plainly to be seen; it does not, however, continue to increase, as would be the case in electrolytic action. By the preliminary trial we have put capillary attraction out of the count; by the proper choice of chemicals we have put electrolysis out of count; we must, therefore, have mechanical transmission by the action of the current. In a second experiment we used a single vessel separated into two compartments by a baked clay porous septum. One of these compartments was filled with liquid and left for 24 hours to see if there was any mechanical leakage, and none occurred. We then filled one compartment with solution of iodine, and the other with a solution of starch. We left this for some hours, but without any mechanical precipitation of starch being apparent. When a small current was passed distinct precipitation took place within an hour. This, however, did not increase very largely by continuing the current. In our experiment upon the living subject the human skin is the porous septum. By this power of mechanical transmission, I hope we can show the effect of complete anæsthetisation.

We have here a pad soaked in a solution of cocaine, this I placed upon the patient's arm upon a patch where there are a few dark hairs. This is covered by a metal electrode connected to a battery. Another and larger pad is placed further upon the arm, and connected to the negative pole of the battery. I hope to send the cocaine into the skin by the process of cataphoric medication by a current of 20 milliamperes, which we will leave for a quarter of an hour. (The experiment was arranged so as to be left on while a part of the paper was proceeded with.) The continued application of the current has produced, you will see, a slight red patch the size of a crown piece. I now insert this platinum needle to the depth of $\frac{1}{16}$in., and the patient, you notice, enjoys the operation. The needle is connected to a battery. I turn on the current of a few milliamperes. A slight effect is seen at the root of the follicle of the hair alongside which I have inserted the needle. This electrolyses the follicle, and now the hair should be quite loose, and comes away, you see, perfectly. The operation has been entirely painless. I repeat this experiment and remove another hair.]

The reading of the paper was then continued as follows:

Taking the facts in order, and certain conditions being observed: 1. We note that a continuous current, passing from one vessel to another along a moistened conductor, will carry with it from + to − sufficient of the drug in solution at the + to produce a precipitate in the solution at the − pole. 2. That a portion of the drug in solution will pass through a porous septum in the direction of current flow. 3. That a portion of a drug in solution will pass into the human body through the skin also in the direction of the current flow, the skin here representing the porous septum.

Repeated qualitative tests have shown clearly that the drug used has passed into the system, and we are now endeavouring to obtain quantitative tests which we hope may lead to the adoption of definite dosage by this method.

While on this portion of our subject, it might be well to refer to some experiments we have made to determine whether electricity can be passed from rubber to rubbed in the act of massage. For this purpose several readings were taken from both operator and patient before and after the operation; and it was found that, while in all cases the patients gained electrically by the rubbing, in most the operator gained also. In some other cases, though the operator gained nothing, or even lost a little, the loss was not at all proportionate to the gain of the patient. These results, we think, are amply accounted for by the fact that exercise seems always temporarily to increase the body currents, provided it be not sufficiently violent or long sustained to cause exhaustion. Massage acts upon the patient by improving the circulation and emptying the lymphatics, and so, to that extent, is akin to gentle exercise; hence the increase of the body currents noted in the patient. Massage is to the operator often more than gentle exercise, and is frequently accompanied by a certain amount of exhaustion. Any gain in body current on the part of the operator is probably due to the exercise taken; but this gain may be rendered negative by accompanying exhaustion. We are thus led to conclude that electricity does not pass from rubber to rubbed in massage.

Since writing the above, our attention has been called to an American invention, which is designed to prove electricity of use to the body in dentistry. It is called a "dental vibrator," and its object is to render painless that very unpleasant operation, "tooth extraction." We have examined and tested it in use, with the result that, as far as our present observation goes, we find it does fully accomplish the elimination of pain.

In conclusion, it may perhaps be well to say a few words by way of summary.

The dangers of electricity to the body are considerable, but, fortunately, they are provided against, and generally in a very secure manner. Consequently, it is probable that possible danger to the body from electricity, as carried by light and power circuits, is smaller than the dangers connected with the use of gas or oil. Still, let it not be forgotten that danger, sharp and sudden danger, lurks in the conductors of such circuits, and therefore none but properly initiated and protected persons should touch or interfere with them. If only the wires or other conductors of light and power circuits be so insulated and placed that, under ordinary circumstances, the body cannot come into contact with them, risk is light and danger small. It, in fact, concerns only the comparatively few whose work necessitates their constant presence among such conductors.

The uses, however, affect a far larger number, and outweigh the dangers to an enormous extent. Electricity is useful to us in health; it is so closely connected with vital function and sensation that very probably life does not exist without it; it is capable of producing such changes in the body that it takes rank as one of the best remedies in disease, and it is also of immense value in many branches of surgery.

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* Paper read before the Society of Arts, Wednesday, March 11.

The true relationship between this marvellous and many-sided agent of Nature, and the various complicated phenomena which together make up the sum of our individual existence, has yet to be found. We venture, however, to think that what has so far been discovered proves the relationship to be beneficent. The more the subject is investigated and studied, the better it will be for the health and happiness of us all.

Discussion.

Mr. Howard Swan said he had watched the progress of these experiments from the beginning with great interest, and believed the investigation was likely to prove very useful. The power of treating a small portion of the human body so that it might be actually cut into without causing pain, needed no words to recommend it to medical men. Though in ordinary houses there was no danger from electric wires, it was useful for the public to know what dangers lurked in the wires, with which they had no business to meddle, especially as recent experiments showed that current of far greater pressure than we had been accustomed to—even up to 25,000 volts were likely to come into use. He had heard of several sets of experiments with regard to electricity being generated in the human body, but did not know whether the actual amount of current had been determined. A friend of his, late cable superintendent to the Eastern Telegraph Company, told him that he had sometimes amused himself by testing both negroes and himself, and found that the potential of Europeans was considerably greater than that of negroes. It varied in different states of health and activity, and it occurred to him that it might be an aid to diagnosis. If the normal current in a healthy state had been determined, it would probably be found to vary in disease. One question was how far the process of digestion gave rise to these currents. If there were any reason to suppose that the human stomach, at a temperature of 100deg., was a primary battery, it might afford a useful hint to electricians, and if they employ, not necessarily a solution of corn, but, say, of coal ground fine, in a battery of which the prototype was the human digestive organ, there might be a great development of primary battery schemes. Dr. Milne Murray read a paper lately at Glasgow, in which he brought forward a very delicate galvanometer of the type spoken of by Mr. Lawrence, in which there was a special arrangement for determining minute physiological currents, and if any further information could be given on that point it would be interesting.

General Philip Smith, C.B., bore testimony, from personal experience, to the value of electrical treatment.

Mr. J. J. Vezey asked how long the insensibility of the skin lasted.

Mr. Jones enquired if the application of cocaine to the skin for 25 minutes, without any electrical action, would not produce a certain amount of anæsthesia.

Mr. Bruce asked if instantaneous photography had been applied in any of these experiments, in recording the physiological effects produced by the current.

Mr. F. Wyles asked if the electrodes were of platinum, and said he had made somewhat similar experiments, using a wet string instead of the lamp wick. It had been found necessary to use a new wet string on each occasion when any important reading had to be taken. He suggested that a syphon tube might be used.

Mr. Henchman thought that possibly the results shown were due in great measure to the action of the cocaine alone. He had been operated upon several times, once or twice seriously, always with the local application of cocaine, and the pain had been very slight.

The **Chairman** said both the dangers and benefits of electricity were now attracting a good deal of attention, and each topic was a very old one. Nearly 150 years ago the first severe operation of the electrical discharge attracted the attention of all Europe, and even in 1759, no less a character than John Wesley wrote a book under the title of "The Desideratum; or, Electricity Made Useful: by a Lover of Mankind and of Common Sense." Some of the sections of that book were peculiar and interesting. For instance: "Electricity, the Soul of the Universe"; "The Cat in the Oven, Curious Electrical Experiment"; "A Person with the Small-pox cannot be Electrified." He did not know whether the author had worked in that direction. Again, "Electricity the Greatest of all Remedies;" and again, one experiment described by Wesley was "A person standing on the ground cannot kiss an electrified person standing on the resin." There was this great distinction between this paper and nearly all that had hitherto been written on the curative qualities of electricity, that it had been illustrated by experiment, and was the result of actual observation. Too often people allowed their imagination to run wild on these matters. The dangers of electricity had occupied a great deal of attention lately, and the Press had given great prominence to accidents which had occurred in the United States. Nearly all these accidents had arisen from men occupied in repairing and maintaining telegraph and telephone wires, who had received severe shocks and had been killed, either instantly by the current, or by being thrown from great heights to the ground. But in these cases the currents were not from the telegraph wires themselves, but from electric light or power circuits which ran on the same poles. Those who had not been in the States could scarcely believe that a nation so far advanced in civilisation would actually allow a street like the Strand to be permeated by poles, each carrying a mixture of wires—some telegraphic, some telephonic, some for fire alarms, and many for electric lights and the transmission of power. The result was you could walk down Broadway almost sheltered from the sun by the cloud of wires overhead. When a poor telegraph man ascended a pole to remove a fault, he might accidentally touch a wire carrying a powerful current, from which he received a fatal shock; but of some 30 accidents he had investigated, about nine-tenths had arisen from this cause. Of course, the cure for such dangers was very simple. The first rule was, never to allow such wires to be carried overhead. All light and power wires worked at high pressure should be carried underground, away from the reach both of the public and the workmen. But in this country there was an element of safety which existed nowhere else that he knew of, and which few people liked—the grandmotherly government of the Board of Trade. But there never was an institution which did more for the life and health of the country than the Board of Trade. Its rules and regulations had made a first-class railway carriage absolutely the safest place to live in; for more people died in their own dining-rooms than in railway carriages. The same with electric wires; if they were put up in accordance with the rules of the Board of Trade there would be almost absolute safety. One important point in connection with the danger from wires was the duration of contact. You might have a current of high E.M.F., and just touch the wire with more than a trifling effect; but if you grasped it, and got muscular fixation, the result would be very serious. Another point of great importance, which had been lately investigated by an American electrician, Mr. Tesla, was the influence of alternating currents of high frequency. The authors spoke of an alternating current of a frequency of 23 to the second; but those used by the Grosvenor Gallery Company were about 70 or 80, and at present the ordinary frequency used was about 100. Mr. Tesla found that the higher the frequency the greater was the amount of electrical energy which might be passed through the body without serious discomfort, which was a point deserving attention. The authors had touched very lightly on a delicate subject, the nature of electricity. Those who spent their lives in dealing with electricity knew least about it, and people did not agree on what the term electricity meant. Practical men called one thing electricity, and the physicist and mathematician applied the term to something else. Passing through the carbon filaments which lighted the room, there was something which many called electricity, but it was really electrical energy. In the same way, heat was one thing and temperature was quite another thing. Electricity was one thing and electric energy was another. Engineers regarded the electricity which was used in lightning distinctly as a form of energy. It was not a substance, a body, but something of an abstract character, which could not be explained; but it had these properties which the authors of the paper had spoken of—curative powers of various kinds, and the peculiar cataphoric power which had been shown by the experiments. The authors trod on very safe ground when they applied their powers of experimenting to solve this intricate question. Tooth extraction had been spoken of, and a friend of his had tried the electrical method and found it so successful that he had eight troublesome teeth removed at one sitting. He concluded by proposing a hearty vote of thanks to the authors of the paper.

The vote of thanks having been carried unanimously,

Dr. Harries, in reply, said it had not been possible, with the instruments at their command, to determine the exact difference of potential at different parts of the body. They found deflections varying from 15 or 20 up to perhaps 40 degrees on the scale of the mirror galvanometer, but what that represented he was unable to say. Each degree might be one-millionth part of a unit, or, perhaps, less, but at present that was only a guess. With regard to the difference noted between negroes and Europeans, that might in all probability be accounted for by a difference in skin resistance. The skin of a negro was usually much thicker than that of a white man, and was the chief factor in the resistance to the passage of currents generated inside the body. The question relating to the process of digestion would admit of a great variety of answers, but he should suppose that where digestion was going on there would be electrolysis, and if so there would be loss of current, not production. On the other hand, where oxidation was going on, as in the lungs, and in the tissues where action was vigorous, where the oxyhomoglobin of the blood was being reduced, you might expect to find production of current. He had not yet seen Dr. Milne Murray's galvanometer. As a rule anæsthesia began to diminish after about 10 minutes, and went on diminishing for half an hour or 40 minutes, depending in different cases on the degree of soakage. The anæsthetic result depended, to a great extent, on good preliminary soakage of the skin, which, lowering its resistance, enabled the solution to pass more readily into the tissues. Where the skin was dry, the process would take longer, and be more difficult. Whether the insensibility was due to the cocaine alone, was a vital point. If the result was due to electricity alone, they would not need to use the cocaine; and if it were due to the latter alone, there would be no occasion to use electricity; it was due to combined action. The application of cocaine alone of the proper strength would have some effect; but when used with the aid of the current it produced such anæsthesia that you could, if necessary, apply a red-hot iron without much objection on the part of the patient. By using this cataphoric process, the galvano-cautère had been applied as much as half-a-dozen times, consecutively, to the same patient, at the same operation, without any sign of wincing. He had seen no reports of the application of photography in noting the effects produced by electricity; but he should be very glad if someone would carry out experiments in that direction, which could hardly fail to be useful, especially in determining the exact dose of current which a patient could bear. As mentioned by Mr. Wyles, they used a fresh wet string or wick at each experiment, as well as platinum or carbon electrodes, avoiding anything liable to easy decomposition. With all deference to John Wesley, he was not right in saying that persons suffering from smallpox could not be electrified. Probably, in those days, insulation was not so perfect as it was now, and the whole subject was not so well understood. Wesley knew a great deal about many things, but he could hardly be called an expert on the subject of electricity. On the subject of kissing he might have had more experience, and his evidence perhaps would be more readily accepted. The duration of contact was an important point which had been alluded to in the present paper, as well as in previous papers referred to. With regard to currents of high frequency, he had dealt with that question both at a meeting of the Institution of Electrical Engineers last March, when he stated that the more rapid the alternations, the more nearly did the conditions resemble those of a constant current as regarded sensation; and at the British Association meeting at Leeds the subject was also dealt with. It was stated that a much larger dose of electrical current could be taken when the alternations were 300 per second than when they were 50 or 60. Everything new, of course, came from America, but in this instance he thought they had got ahead of Mr. Tesla. Certain other specially electrical matters he would leave his colleague to deal with.

Mr. Lawrence said he had very little to add. They had referred in the paper to the danger which might arise incidentally from telegraph wires being in the neighbourhood of those carrying stronger currents, and in regard to the point raised by the chairman about the nature of electricity, he should be very sorry for it to be supposed that they had the remotest intention of attempting any explanation of the kind. They had only referred to electricity as it was used, and as the chairman had differentiated between electricity and electrical energy, he might explain that they intended to speak only of electrical energy.

PHYSICAL SOCIETY.—March 20.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

Prof. S. U. Pickering, F.R.S., read a paper on "**The Theory of Dissociation into Ions and its Consequences.**" According to this theory electrolytes are entirely dissociated into their ions in weak solutions. This dissociation was held by Arrhenius to absorb heat, and although heat is evolved by the dissolution of hydrochloric acid, etc., it is not maintained that dissolution evolves heat, but that the heat absorbed by the decomposition of the molecule into its atoms is more than counterbalanced by the heat supposed to be evolved by the combination of the atoms with their electric charges. These actions the author considered improbable, and thought that before being accepted the theory must give satisfactory answers to the following questions: How can matter combine with an affection of matter to produce heat? Whence do the electric charges originate? Why does not the opposite electrification of the different atoms make them cling more firmly together, instead of dissolving the union between them? And, why should an atom which possesses a strong attraction for a negative charge (such as chlorine) go to the positive electrode during electrolysis? When a dilute solution, which is supposed to contain some gaseous molecules, is further diluted, then, according to the theory, some of the molecules are dissociated, and if heat is absorbed, it follows that the dissociation, and therefore dissolution, of the gas must absorb heat; yet, he said, it can be shown that in some of these cases the dissolution of a gas evolves a large amount of heat. The antagonism between the present and the old electro-chemical theory, according to which the atomic charges are identical with the free energy of an atom, and are the cause of combination, not decomposition, was commented on, as well as the disagreement between the present theory and Clausius's view that there are a few ions or atoms present in a liquid owing to accidental superheating of some of the molecules. Reasons, however, were adduced for believing that the presence of even a few atoms in a solution to be improbable.

A communication on "**Some Points in Electrolysis**" was made by **Mr. J. Swinburne**. Considering a reversible single-fluid cell, the author, by a process of reasoning based on Carnot's principle and the conservation of energy, arrives at Helmholtz's equation, $E = E_c + \theta \frac{dE}{d\theta}$, where E is the E.M.F., E_c the part due to chemical action, and θ the absolute temperature. Writing the equation in full, using suffixes n and p to denote the negative and positive plates, it becomes

$$E_n + E_p = E_{nc} + E_{pc} + \theta \frac{dE_n}{d\theta} + \theta \frac{dE_p}{d\theta}.$$

He then shows that by having the two plates in different vessels, and heating them to different temperatures, the Peltier effects represented by $\theta \frac{dE_n}{d\theta}$ and $\theta \frac{dE_p}{d\theta}$, can be determined separately. Similarly, those of a two-fluid battery might be found by arranging the junction of the fluids in a third vessel. After pointing out the desirability that the conditions under which all thermo-chemical data have been obtained should be clearly stated, he proceeded to show that any cell in which secondary actions occur (as, for example, if zinc oxide primarily formed by electrolysis were to dissolve in sulphuric acid) must necessarily be non-reversible. He also contended that in a secondary battery the formation of lead sulphate on both plates is the essence of the cell's action, and that there is no intermediate formation of PbO. On the subject of so-called "nascent" hydrogen or oxygen, he said that reasoning from the conservation of energy showed that neither could exist. Taking the case of persulphate of iron in dilute sulphuric acid, which is said to be reduced to protosulphate by the "nascent hydrogen" liberated on putting a piece of metal, say, magnesium, into the liquid, he said a better explanation of the phenomena would be that the metal dissolves, if it either reduces the metal or evolves hydrogen; and as the former requires less energy, the reduction takes place, and when no reducible salt is available, hydrogen is evolved. Evolution of hydrogen and reduction of the per salt are thus alternative and not consecutive actions. Examining Dr. Lodge's views on the contact E.M.F. between metals, he remarked that if the tendency of a metal, such as zinc, to oxidise can produce an electric stress or difference of potential, which presents further combination, actual combination must charge the metal if it be insulated. A piece of sodium, however, oxidises continuously, and therefore should become charged to an enormous potential. As this effect is not known to occur, the author suggested that the Volta effect may be due to films of water, and in support of this view adduced the fact that metals when perfectly dry do not combine with chlorine, and that even sodium is not attacked by dry chlorine.

In the discussion on the two papers, **Prof. Pickering** said the idea of nascent elements had, to a large extent, been given up by chemists, and pointed out that the fact of one reaction taking place rather than another was not merely a question of heat energy, but that a kind of chemical selection was involved. **Prof. S. P. Thompson** recalled attention to the fact that the products of electrolysis depend on the E.M.F. employed in producing it, and thought the E.M.F. required to produce the various products might be taken as a measure of their affinities. He did not agree with Mr. Swinburne's method of finding the E.M.F. of a secondary battery from thermo-chemical data, for he failed to see how two similar actions going on at the two plates of a cell could add anything whatever to the E.M.F. of the cell. The **President** said the question whether the potential difference between two dissimilar substances was due to oxidation or to mere contact, could only be decided by direct experiments made in a vacuum from which all traces of moisture and oxygen had been removed. Without agreeing with Dr Lodge's view on the subject, he pointed out that the continuous oxidation of a piece of insulated sodium need not necessarily produce a great potential difference, for the combination might produce heat.

After Prof. Pickering and Mr. Swinburne had replied to the points raised, Mr. Walter Baily took the chair; and **Prof. Perry** read a note "**On the Variation of Surface Tension with Temperature,**" by Prof. A. L. Selby, M.A. Considering unit mass of liquid at constant volume, but variable surface, S, and temperature t, the author expresses the gain of intrinsic energy due to changes of the variables by $dH + dW = h\,dt + (l + T)\,dS$, where dH is the heat absorbed, dW the work done on the film, h the specific heat at constant volume, l the latent heat of extension, and T the surface tension. This being a perfect differential, it is shown that $T = c - bt$, and $l = bt$, c and b being constants. Supposing c and b to be independent of the specific volume of the liquid, it is shown that at the critical temperature $t = \frac{c}{b}$; hence this temperature may be determined by finding the surface tension at two very different temperatures. Since also $l = b\,t$, the latent heat of extension is proportional to the absolute temperature. Reasons for supposing b to be independent of the specific volume are given in the paper. **Mr. Blakesley** described an effect of temperature on surface tensions which he had observed in sensitive spirit levels. By warming one end of the tube, even by the hand, the bubble immediately moves towards that end. This effect, which might produce considerable error in engineering operations, was, so far as he was aware, not mentioned in the text-books. **Prof. Perry** remarked that although the volume, temperature, and surface of the liquid had been referred to in the paper, pressure was not mentioned, and on this point he enquired whether the results arrived at were true quite independent of the pressure.

Prof. S. P. Thompson, D Sc., read a paper on "**Magnetic Proof Pieces and Proof Planes.**" The distribution of magnetism over magnets has been examined in various ways by different observers, but mostly by observing the force of detachment of either rods, ellipsoids, or spheres used as proof pieces. In all these cases it was, the author said, difficult to see exactly what was measured, for the presence of the proof pieces altered the thing to be tested. The pull exerted must also depend on the permeability of the piece used as well as on its shape and disposition with respect to the magnetic circuit. He had, therefore, investigated the subject, by finding the actual distributions by means of a flat exploring coil and ballistic galvanometer, both with and without the presence of proof pieces of various shapes and sizes. The results show that the perturbations produced by the proof pieces are always large, in some cases the perturbed field about a point being four to six times the imperturbed field. In most cases, however, the ratio of the perturbed to the imperturbed field was constant so long as the former did not exceed 6,000 C.G.S. units. The amount of perturbation was also found to depend on the saturation of the magnet, and on whether it was a permanent or an electromagnet. The numbers obtained in various experiments and curves plotted from such results were shown. In conclusion, the author said that in using proof pieces much depended on the accuracy of the contact, but in any case the results obtained were not very reliable. The flat exploring coil, or magnetic proof plane, however, furnished a satisfactory method of examining magnetic distributions.

LEGAL INTELLIGENCE.

FAREHAM LOCAL BOARD v. SMITH.

The further hearing of the motion in the action of the Fareham Local Board against Mr. Smith, which it was arranged should be treated as the trial of the action, was resumed recently, before Mr. Justice Chitty in the Chancery Division. The motion was for an injunction to restrain Mr. C. B. Smith from removing or cutting electric wires, erected by one of the plaintiffs, the Fareham Electric Light Company, with the leave and under contract with the Fareham Local Board for the electric light to a considerable part of Fareham, Mr. Smith having threatened in writing to do this; and it was sought to restrain him.

Mr. Smith, the defendant, is an estate agent and the owner in fee simple of a piece of land bounded by Osborne-road, along which the wires in question have been placed, and he is also one of the directors of the Fareham Gas Company. When the case was last before the Court it was urged on behalf of the defendant that the Board of Trade had given no license or provisional order to plaintiffs to erect the wires as required under the Electric Lighting Acts of 1882 and 1888, and, further, that section 174 of the Public Health Act, which provides that before an authority enters into a contract to supply the electric light public notice of the contract should be given, had not been complied with. It was contended on the last occasion, on behalf of the plaintiffs, that even if the Board of Trade had not granted a provisional order or license to the company to lay the wires, it would not justify the defendant in cutting them. It was also stated, on behalf of the defendant, that he had no objection to the electric wires provided they were placed underground. Some discussion arose when the matter was last before the Court as to the ownership of the land claimed by defendant, the plaintiffs affirming that the defendant had not established his claim to it, and that until he had proved that the property was his he could not sustain a charge of trespass against the plaintiffs. The matter was ordered to stand over to enable additional evidence as to the defendant's ownership of the land to be produced.

Mr. Whitehorne, Q.C., and Mr. Green represented the plaintiffs, and Mr. Henn Collins, Q.C., was counsel for the defendant.

Mr. Henn Collins, in reply to his lordship, now said that he still held that the defendant was the owner of the soil up to the middle of Osborne-road, whether it were at the time the act complained of a public or a private road.

Mr. Justice Chitty: At the time of the conveyance of this land was Osborne-road a private road?

Mr. Whitehorne replied in the affirmative, and proceeded to lay before the Court the additional evidence.

His **Lordship**, at the conclusion of the arguments, said he would take time to consider his judgment. He probably would not be able to give it before next term.

PROVISIONAL PATENTS, 1891.

MARCH 23.

5131. **Means for applying electricity through jets, streams, or sprays of fluids and vapours for therapeutic and other purposes.** Henry Newman Lawrence, 35, Fitzroy-square, London.

5135. **Improvements in armatures for dynamos or electric motors.** Barron Douglas Southard, 1, St. James's-square, Manchester. (Complete specification.)

5162. **Improvements in devices for transmitting power, the same being specially adapted for use with electric motors, propelling cars, or vehicles.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Edward H. Johnson, United States.)

5167. **An improvement in the manufacture of tubes by electrolysis.** Francis Edward Elmore and Alexander Stanley Elmore, 28, Southampton-buildings, London.

MARCH 24.

5192. **Improvements in electric clocks.** William Soule Scales, 55, Chancery-lane, London. (Complete specification.)

5252. **Electric signal apparatus for railway trains.** Edwin David Graff, 1, Queen Victoria-street, London. (Complete specification.)

5280. **Improvements in electric switches.** William Phillips Thompson, 6, Lord-street, Liverpool. (Willing and Violet, Germany.) (Complete specification).

MARCH 25.

5313. **An improvement for driving electrical machinery.** Hector Aylesbury, 3, Unity-street, College Green, Bristol.

5318. **Improvements in or relating to arc lamps.** Frederick Richard Boardman and Joseph Sinclair Fairfax, 433, Strand, London.

5329. **Improvements in portable electric safety lamps.** Lars Bristol, 70, Chancery-lane, London.

5338. **Improvements in the form of carbons used in certain electric arc lamps.** Thomas Philip Christopher Crampton and Albert Essinger, 38, Holborn-viaduct, London.

5341. **Improvements in electrical transformers.** Arcadius Poleschko, 24, Southampton-buildings, London.

5343. **Improvements in electric arc lamps.** James Brockie, 28, Southampton-buildings, London. (Complete specification.)

5342. **Improvements in electrical thermometers or pyrometers.** Hugh Longbourne Callendar, 24, Southampton-buildings, London.

5350. **Mounting electrical dynamo machines or motors to enable them to be easily reversed for driving in alternate directions.** Richard Robert Harper, 166, Fleet-street, London.

MARCH 26.

5370. **Improvements in and connected with dynamos or other electric generators, and motors and accumulators, and other appliances.** Philip Henry Williams, Egham, Surrey.

5371. **Improvements in and connected with telephones and telegraphs, and apparatus and appliances therefor.** Philip Henry Williams, Egham, Surrey.

5404. **Improvements in or relating to fittings for electric and other lamps.** Joseph Clift, 70, Chancery-lane, London.

5406. **Improvements in attachments for telegraph poles for carrying insulators.** Howard Cochrane Jobson, 7, Staple-inn, London.

5412. **Improvements in means for supplying electricity to electric tramways or railways.** Thomas Parker, 47, Lincoln's-inn-fields, London.

5435. **Improvements in electric magnetic massage kneaders.** David Lichtenstadt and Charles Lichtenstadt, 45, Southampton-buildings, London. (Date applied for under Patents Act, 1883, Section 103. 8th December, 1890, being date of application in United States.) (Complete specification).

MARCH 28.

5461. **Improvements in masts and trolleys for the overhead system of electric traction.** Alfred Dickinson, Darlaston, South Staffs.

5485. **Improvements in the means for telephonic communication.** Etienne Massin, 28, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1890.

5135. **Cores for converters, etc.** Belfield (Westinghouse Electric Company). 8d.

5368. **Telephony.** Kellogg. 11d.

5369. **Telephony.** Kellogg. 8d.

5925. **Telephony.** Kellogg. 11d.

6945. **Electric switch.** Appleton. 8d.

7599. **Electric arc lamps.** Belfield (Lange). 8d.

9861. **Electrical storage batteries.** Boult (Tommasi and another). 8d.

13791. **Incandescent electric lamps.** Lake (Hobby). 6d.

15413. **Arc electric lamp.** Grant. 6d.

18890. **Telephone connectors.** Johnson (Automatic Electric Exchange Company). 2s. 9d.

19191. **Electric railways, etc.** Wheless and Wheatley. 1s. 1d.

21045. **Electrical conductors.** Walton. 6d.

1891.

2061. **Electric lampholders.** Thompson (Moore). 8d.

CITY NOTES.

Western and Brazilian Telegraph Company.—The receipts for last week were £4,431.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £5,427.

Oriental Telephone Company.—The transfer-books of this Company will be closed from April 6 to 15, both days inclusive.

City and South London Railway.—The receipts for the week ending March 28 amounted to £702, against £766 for the previous week. The total for the month was £2,948, against £2,875 for February.

Submarine Cables Trust.—Notice is given that, on and after April 15, the coupon due in October last will be paid in full by Messrs. Glyn, Mills, and Co., of Lombard-street. Certificate holders are requested to present the coupons for October, 1890, only, and not those payable on April 15, 1891.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2¼
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼

NOTES.

Edinburgh Public Library.—The electric light for this building cost £1,942.

Prof. Tyndall, we are pleased to hear, is slowly progressing towards recovery.

Telephone.—The trunk line between Newcastle and Consett will be opened this week.

Matlock Bath.—The report of the engineer with regard to the electric light has been presented.

Austria.—In Austria-Hungary there are now 185,000 incandescent and 4,000 arc lamps supplied by 1,200 dynamos.

Western Australia.—An electric light company is about to be established to illuminate Perth, Fremantle, and Albany.

Gas Ousted.—All the gas lamps in the city of Chattanooga, Tenn., have been cut off, and the city is now lighted entirely by electricity.

Long Traction Lines.—It is reported that about 70 miles of new track will be laid this year by the Electric Car Company at Minneapolis.

Potsdam.—The German Gas Company of Dessau has purchased a large site at Potsdam for the erection of a central electric lighting station.

Vienna.—The Imperial Palace at Vienna, already lighted by 2,000 lamps, is to have 2,000 more to furnish the entire lighting in every room.

Manchester Town Hall.—The Mayor at the last meeting of the Manchester City Council suggested that the Town Hall had better have a separate installation.

One of a Legion.—The Exchange Telegraph Company states that the French Government has made Sir John Pender, K.C.M.G., a Grand Officer of the Legion of Honour.

Telephone at Tunis.—A telephone exchange has been opened connecting Tunis with La Marsa and La Goulette. At present there are 73 subscribers and 70 miles of line.

Telephoning to the South of France.—Speaking has been accomplished through the Paris telephone cable direct to Marseilles, a distance of over 700 miles, with perfect success.

Cable Rates.—The agreement for the reduction to 4s. a word of the cable rates from England to Australia (except New Zealand and Queensland) has been signed, and comes into force on the 1st prox.

Electrolysis of Acids.—Before the Edinburgh Royal Society, on Monday, Prof. Crum-Brown and Dr. James Walker read a paper "On the Synthesis of Dibasic Acids by Means of Electrolysis."

Smoking Concert.—We may remind our readers that to-night (Friday) an evening's enjoyment awaits them at St. James's Hall Restaurant in the shape of an Electro-Harmonic smoking concert.

Removal.—Mr. A. W. Bennett, electrical engineer, of Leeds, has opened new offices and showrooms, with works at the back, at 36, Portland-crescent, Leeds, and manufactures switches, bells, and dynamos.

Menton Asylum.—The Committee of the West Riding County Council reported that they had accepted the tender of Messrs. Woodhouse and Rawson to light one of the blocks and corridor by electric light.

Newcastle.—The offer of the Newcastle Gas Company for public lighting has been accepted on the understanding that the Corporation should be at liberty to light such lamps as they thought fit by electricity.

Telephone in Spain.—A project is on foot at Madrid for the immediate installation of an interurban telephone system, connecting the 49 chief towns of Spain, Madrid being the situation of the central exchange.

Sale of Plant.—Messrs. Wheatley Kirk, Price, and Goulty have for sale, by private treaty, plant and machinery at Haggerston; and also several Marshall and Babcock boilers and Siemens dynamos. For particulars, see elsewhere.

Invention of the Edison-Swan Lamp.—The lawsuit pending between the Edison-Swan Company and the French agent of the Khotinsky lamp is stated as likely to be filled with piquant details of the history of the incandescent lamp.

Aluminium for Motors.—A suggestive note states, though without going into the comparative costs, that a reduction of no less than 45 per cent. in the weight of motors for electric cars can be secured by using aluminium in their construction.

Glasgow Library.—At the Glasgow Town Council's last meeting, the Gas and Electric Lighting Committee's minutes contained a clause recommending that the Mitchell Library be lighted with electricity at a cost of £762. 16s., which was agreed to.

Underground Pipes.—At Birmingham, where the underground lines of the National Telephone Company have been laid 3ft. underground, and side by side, it is suggested that they should be laid vertically to allow easier access to gas mains below.

Death.—M. Pouyer-Guertier died on Thursday morning, the 2nd inst., at Rouen, having reached the age of 71. In the electrical world he will be remembered as having been actively connected with the laying of the French Atlantic cable. He owned a large cotton spinning factory at Rouen.

City and South London Frontages.—The case of the London County Council against the City and South London Railway came before the Court upon the question of frontages beyond the general line, at Lambeth, on Monday, and was adjourned until the decision of similar cases before the Superior Court was declared.

Bristol.—We understand that arrangements have been made by the Bristol authorities by which Mr. Preece and Mr. Gisbert Kapp will co-operate in the designing and superintending of the Bristol central electric station. Plans will be prepared, and the work carried out by the various contractors for the authorities themselves.

Electrical Engineers Busy.—All electrical companies in the United States are reported as overcrowded with work. There is a demand for expert electrical engineers. An underground electric railway system is proposed in New York. It is proposed to build four tracks under Broadway, from the battery to Harlem River.

Church Lighting.—The electric light is to be introduced into one of the City churches. The Rev. H. C. Shuttleworth, the rector of St. Nicholas Cole Abbey, discovered that the heat from the gas interfered with the musical services, for which his church is famous. Hence the resolve to supplant it with the electric light.

Rotating Carbons.—A new arc lamp, burning 500 hours, is being brought out by a company in Pittsburg, U.S. The carbons are made of the shape of small emery wheels, 4in. and 8in. in diameter respectively. They are placed at right angles to each other, the larger one over the smaller one, and are kept rotating by a suitable electrical arrangement.

Royal Institution.—On Friday (to-night), at 9 o'clock, Sir William Thomson, Pres.R.S., will read a paper on "Electric and Magnetic Screening." To the Friday evening meetings members and their friends only are admitted. On Saturday, April 11, at 3 o'clock, Prof. Silvanus P. Thompson will deliver the first of four lectures on "The Dynamo." Tickets half a guinea.

Electrical Convention in Canada.—Preparations are being made for a great electrical convention in Montreal during August, including an exhibition of apparatus made by Canadian and American electrical engineers. Principal Dawson, of M'Gill University, and Prof. Bovey, Dean of the Faculty of Applied Science, are contributing towards the success of the occasion.

Telephones at Swansea.—The Committee of the Swansea County Council recommend the acceptance of the tender of Mr. John S. Brown to construct a telephone line between the Guildhall and the storage reservoirs at Velindre, for the sum of £670; and that a contract be entered into with Mr. Brown for the maintenance of the line for a period of seven years at £24 per annum.

Buda-Pesth.—A company has been formed under the presidency of Count Szapary, with a capital of three million florins, to take over the Siemens-Halske electric railway at Buda-Pesth. The Minister of Public Works has submitted a project for the public lighting of the town, and tenders are invited. It is whispered, however, that a certain celebrated firm in the neighbourhood will probably get the order.

Prices.—At Erie, New York County, it is reported that an electric company has offered to install a plant on a 10 years' contract at £15 per year per 1,200 c.p. arc lamp, and sell the plant at cost to the city at the end of this time. A village in Illinois has received an offer to light 100 street lamps at 1dol. (4s. 2d.) a lamp each, and at Waco, Texas, the local gas company have contracted to furnish 50 arc lights, of 2,000 c.p., at the remarkably low rate of 3s. 9d. per month per light.

Glycerine Lenses.—Lamps will be shown at the approaching Naval Exhibition with lenses designed and patented by Captain A. J. Loftus, of the Siamese service. The distinguishing feature of these lenses for ship's lights is a layer of coloured glycerine between ¼in. sheets of plate glass. The colours, according to Government tests, are more vivid than with ordinary lenses, red being distinguishable at 9,000 yards and green at 6,000 yards. They are practically unbreakable, and should be useful in combination with electric light signal lamps.

Indiarubber.—At a meeting of the Andersonian Chemical Society at Edinburgh a lecture was delivered by Charles A. Fawsitt, F.R.S.E., F.C.S., on the "Vulcanisation of Indiarubber." The lecturer entered into the history of the various processes of vulcanisation, described and criticised the methods, and gave his own experience in the business. He then proceeded to point out numerous openings for chemical research in the industry, and made suggestions as to the best way in which to carry it out. The paper was very interesting, and was listened to with close attention.

Charging Stations.—Messrs. Woodhouse and Rawson inform us that they have arranged for the erection of a permanent charging station on the banks of the river at Chertsey, under the management of Mr. J. Taylor. The station is now in course of erection, and will be quite ready to undertake the charging of all sizes of electric launches by the beginning of the river season. We are glad to hear it, and we would add that as soon as any new charging station is arranged to supply light in the winter, and current for motive power in the summer, we shall be pleased to have full information.

York.—At the monthly meeting of the York City Council, Mr. Johnson expressed his opinion that the lighting power of the gas supply to the city was exceedingly low. He moved that the town clerk secure information showing how York stands among the large towns in the kingdom in regard to the lighting power of the gas supply, and what towns have their gas analysed before being supplied to the consumer. Mr. Dodsworth seconded the motion, which was passed. While the town clerk is having his attention directed in this direction, it would be well if electrical engineers were to furnish him with information upon electric lighting.

Rochdale.—The Gas Committee, at the last meeting of the Rochdale Town Council, recommended extensions of the gas works at a cost of £60,000. Councillor Duckworth regarded the great increase in the consumption of gas as an indication of the progress and extension of the town. He would, however, like to know whether the committee, in the extension of the works, intended to provide the town with electric lighting. Alderman W. J. Petrie replied that the space at the gas works was little enough for the gas extension plant, and the committee did not yet think it wise to go into the electric lighting business. If they decided to do so, they would erect works in a different part of the town.

Electric Clock Dials.—The method of distributing time by one clock and a set of dials actuated by electric magnets energised from the central clock, invented by M. Blondeau, is described with a diagram in *L'Electricien*, No. 7, 1891, p. 106. A system somewhat of this kind is, we believe, being now tested in the General Post Office, London. The hand in the dummy dial moves by half-minutes, and the set of clocks is of course remarkably cheap when compared with a similar number of timekeepers regulated only by the electric current. In M. Blondeau's system a cogged iron wheel is pulled round step by step by a magnet, a ratchet preventing more than one step being taken at a time.

Weems Express.—Plans for passenger trains, at 150 miles an hour on the Weems electric express system, have been drawn out under the direction of Mr. O. T. Crosby, and have been pronounced practical by Prof. Rowland and Dr. Duncan, of Johns Hopkins University. A motor car, with two passenger cars, will be run on a track having two lower rails and one upper rail—a kind of cage track. The motor car is to weigh 18 tons, with 7ft. driving wheels, a motor being coupled directly on each axle. The total cost of double track, 1,000 miles long, is estimated at £16,000 per mile, including conductors, rolling-stock, stations, and engines, for a plant of 100 passenger cars and 50 engines.

Electric Tramways in Bremen.—The Bremen Tramways Company has just decided to remove its horse cars from its lines and to substitute electric tramcars for the whole of the service in that town. The company has been induced to come to this decision on account of he excellent commercial and working results obtained with an experimental line laid down last summer. It is intended to adopt the Thomson-Houston overhead wire system, which is the method used in the trial tramway. The Imperial postal authorities objected to the use of the overhead conductor, owing to the interruption in the telephone service, but, notwithstanding this, the police authorities have already given their permission for the use of the system. The

Senate is also prepared to give consent, and horse tramcars will, therefore, disappear from the streets of Bremen.

Testing Steel and Iron.—A Swedish engineer has recently applied electricity to testing steel and iron for its hardness. It is well known that an electric current of sufficient strength will fuse a thin slip of metal or wire when passed through it. By making a number of experiments the engineer has found, says the *Globe*, the strengths of current required to fuse test pieces of iron and steel of different degrees of hardness, and has formed a scale of currents corresponding to a scale of hardness. In order to find the hardness of a particular test piece of the metal it is only necessary to find the current required to fuse it, and this can easily be done by means of an ampere-meter. The corresponding figure on the scale gives the hardness of the piece.

Efficient Transmission of Power.—An electric plant is being installed at Telluride, Colorado, by the Gold King Mining Company. The gold ore at this place is abundant, but of such low grade that the operating expenses until recently were barely covered. The machinery was driven by steam engines, but fuel is now scarce, and the manager recently decided to utilise the water power in the vicinity. A dam was built across the San Miguel River, which falls 500ft. in less than a mile at this place, and from the headgate the water is taken through a 4,000ft. pipe, gradually decreasing in diameter from 20in. to 12in., to the power station, where it is delivered to two 6ft. Pelton wheels. Westinghouse machinery is used, and the loss in transmission between generator and motor, says the *Engineering News*, over a 2½-mile circuit is said to be barely 5 per cent.

Underground Telephone Wires.—At a meeting of the City Commission of Sewers on Tuesday a report was brought up from the Streets Committee on the application of the National Telephone Company to place a portion of their telephone cables beneath the public ways, recommending that permission be given for the work, so far as the company could arrange to do it, simultaneously with the electric lighting companies. A letter was read from the Brush Electrical Engineering Company pointing out the question of laying telephone cables in the same conduits with electric wires was one which required the gravest consideration; and pending further investigations the company hoped the Commission would defer a final decision on the subject. After some discussion, the matter was referred back to the Streets Committee to examine and report.

Nottingham.—At last week's meeting of the Nottingham Town Council, Mr. Adams asked the chairman of the Electric Lighting Committee what had been done with reference to the tenders the committee had received from companies willing to undertake electric lighting in the borough; whether any report was ready, and, if not, would the chairman of the committee give the Council such information on the subject as he might feel justified in doing. The chairman (Alderman Sir John Turney) said the committee had received tenders for carrying out the work, but, owing to circumstances, those tenders have not yet been dealt with. It is the intention of the committee during the next few days to meet and consider those tenders. He thought the committee would probably prefer some responsible contractor or some body of electricians should undertake to do the work instead of doing it themselves.

Self-Induction.—Prof. James Blyth, of Anderson College, exhibited an experiment in self-induction before the Philosophical Society of Glasgow on Wednesday. It consisted in sending a periodic current got by a tuning fork interruptor through two conducting circuits arranged in parallel. The one circuit contained a monochord wire, and a coil whose self-induction could be altered; while the other contained a horseshoe electromagnet placed astride the wire so that the wire was free to vibrate in the narrow gap between its poles. It was shown that the wire sounded loudly in unison with the fork when the phases of the two currents agreed; but that it stopped entirely when the phases were made to differ by altering the self-induction of the circuit. It was pointed out that by an arrangement such as this coefficients of induction could be compared. A vote of thanks was awarded to Prof. Blyth for his interesting experiments.

Uninflammable Mouldings.—Now that concentric wires, interior conduits, and other systems are striving to displace the time-honoured casings, by suggestions that a slight leak is all that is required for the wood to burn up, it is evidently time that a novelty for what Mr. Heaphy terms "hazardous risks" should be introduced. It comes in the form of a new patent fireproof casing for electric light leads, made of plaster, well incorporated with that most useful of waste products—silicate cotton or "slag wool." By this combination high insulation, non conduction of heat, and absolute uninflammability is ensured, and for use under floors, in concealed positions, and for important buildings should be very useful. The casings are supplied by Messrs. Gritten and Parmley, 8, High-street, Notting Hill Gate, W., and are made to any design, to curves of any shape, and are particularly adapted to the ornamental panellings of ceilings and walls.

Weybridge. — Mr. H. E. Paine produced to the Chertsey Rural Sanitary Authority on Tuesday a copy of the Laing, Wharton, and Down Electric Supply Syndicate's provisional order in the form in which they propose to issue it. The Board of Trade, who had sent the order, asked that if the Authority had any observations to make they should be forwarded at once. The syndicate proposed to register a separate company for the purposes of the order, and had requested the Board of Trade to grant an order to that company. According to a letter read at the time it appears that a limited company, with a capital of £15,000, would be registered, and that application for registration was to have been made on March 26th. An agreement has been prepared for the transfer of the electric lighting works and plant at Weybridge, together with the contract made by the syndicate with the lighting inspectors, to the new company, which will be consolidated at an early date. No objections were made, and it was therefore decided simply to acknowledge the receipt of the order.

Electric Light in the House of Commons.—Mr. Labouchere, on Monday night made an onslaught in the direction of economy by enquiring what was the reason of the sum of £1,900 still charged for oil lamps in the House, and suggested that there was a middleman who derived a huge profit therefrom. He thought the First Commissioner of Works should keep a return of the cost per lamp in the House, as many persons had found electric meters very incorrect. Mr. Plunket, in answer, said the electric light was not installed in the rooms where oil was used. Electric lighting, at all events at present, was more costly than oil and gas, and now costs £1,300 a year. He would make enquiries as to checking the cost. Mr. J. Rowlands wished to know whether the electric light could not be extended throughout the House, and Mr. Conybeare also desired the substitution of electric light. Dr. Cameron hoped that an electric light would be adopted that would enable hon. members to read by it. The present electric light was of a most unsatisfactory character. Mr. Plunket was understood to say that he would enquire into the whole matter, and see what could be done.

Manchester Railway Station.—The Lancashire and Yorkshire Railway Company have adopted the electric light for the lighting of Victoria Station, Manchester. The installation consists of 40 2,000-c.p. lamps of the Brockie-Pell type, and the light is remarkably steady. The lamps are arranged on four circuits of 10 each, so interlaced that in the event of a breakdown of a portion of the machinery no part of the station will be left in darkness. The generating plant consists of three dynamos, constructed by Messrs. Mather and Platt. These are placed in the engine-house adjoining the head offices of the company. Two locomotive engines, which have been deprived of their wheels and otherwise adapted for the purpose, are used for driving the dynamos through countershafting. Two only of the dynamos are used at once, the third being held in reserve. Each machine will generate sufficient current for half the lamps in the station. The whole of the installation has been carried out by the railway company's electrical staff, and the work throughout is thoroughly substantial. It is intended ultimately to lay down a much larger plant in a more central position, from which the whole of the station, offices, and approaches will be lighted.

Telegraphing to Lighthouses.—Mr. P. V. Luke, C.I.E., Director of Telegraphs, India, writing from Jersey to the *Standard*, says with regard to telegraphic communication to floating light vessels: "No doubt there are some practical difficulties in the way of mooring a telegraph cable to a floating body, but is it not possible to effect the communication without the aid of a complete metallic circuit? Telegraphing across water by means of uninsulated wires, or without any wires at all, has long been known to be practicable under certain conditions, and an account of what has already been done in this direction will be found in an interesting paper by Mr. W. F. Melhuish, and the discussion on it was published in the *Journal* of the Institution of Electrical Engineers, Vol. XIX., No. 87, issued May, 1890. Sir Charles Bright, in his remarks on the paper, pointed out how the experiments described appeared to indicate a possibility of finding a solution ot the problem of establishing telegraphic communication between lightships and the shore, and Mr. Granville described a method employed in some experiments made by Mr. Willoughby Smith, by means of which communication was actually established without a complete metallic circuit between the shore and a boat moored some quarter of a mile from the shore, with the aid of the telephone and vibrating sounder. Without describing the actual methods employed, I think I am justified in saying that experiments have shown that the difficulty anticipated by Mr. Wren in establishing electric communication with a floating lightship can be overcome, and that this problem need not stand in the way of his excellent and desirable scheme being efficiently carried out."

Caversham.—At the meeting of the Caversham Local Board last week the clerk reported that he had made enquiries as to the best method of lighting Caversham, with electricity or gas. As to gas, he found that at 14 c.p. to 16 c.p. for full time all the year round, 3,900 hours in the year, they would cost about £4. 3s. 2d. per lamp. Each lamp-post would cost about 50s. With regard to the electric light he was unable to give much information; the manager, Mr. Yeatman, wanted more particulars. First of all, he wanted to know whether they could have power from Mr. Lawes's mill, or whether they would have to put down new plant, the power at Reading not being strong enough. They must have 60 h.p., and he was afraid there was not enough water power at the mill. To light with incandescent lamps, the cost would be about £10 per lamp per annum as nearly as he could say. They would require about 30 lamps; it might be less, as compared with 45 gas lamps. Weybridge was lighted by the same company with electricity at £2. 5s. per lamp per annum. He did not know whether they got power from the river at Weybridge. It would be well to form a committee to meet Mr. Yeatman to consult as to the cost, because at the present moment he said it was impossible to give any estimate. Mr. Simonds said they could not get any water power without Mr. Lawes's permission. The surveyor said that Mr. Yeatman suggested that a committee should go to Weybridge. The chairman said he was told by an electrician in London that, roughly speaking, electricity cost half as much again as gas to lay down and half as much again to work. The question was adjourned to the next meeting to obtain information from Weybridge.

Exhibition at the Civil Engineers.—On the occasion of Mr. Crompton's paper, on Tuesday, before the Civil Engineers, a goodly array of machinery and apparatus was on view, forming a select and interesting exhibition for members. A small Parsons turbo-generator for 10,000 revolutions per minute for 15 16-c.p. lamps was on view. The Electric Engineering Corporation showed fittings, switches, and Drummond's safety fittings for mines. Messrs. Woodhouse and Rawson had switchboards galore on view, with a sample of the very pretty little instrument devised by Mr. R. J. Jones for the automatic testing of the circuit, now shown in its commercial form. Messrs. Drake and Gorham, besides their slip-in fuses and earthing device, had two very interesting pieces of apparatus—one was a double-pole switch, one of the easiest, neatest, and most recommendable we have seen; the second, an automatic cell regulator, with small motor working along screw shaft, which tips over mercury contacts to the cells one after the other as the potential rises or falls. Aron meters, Schaeffer and Budenberg's tachometers, and Richards's registering instruments could be seen in action. Sir David Salomons had his automatic station regulator, and Messrs. Goolden a case of station fittings. Crocker-Wheeler motors to drive small pumps and fans were, naturally, on show. The Victoria incandescent dynamo, resplendently new, was accompanied by a number of ingenious cut-outs, resistances, and switches by the Brush Company. Messrs. Rashleigh, Phipps, and Dawson showed their ray diffuser, and Messrs. Osler some beautiful china figure lamps. Messrs. Hedges and Lowrie's electric "satety valve" for high-tension circuits created interest, and one of the most noticeable features was a complete set of concentric wires and fittings by Messrs. J. D. F. Andrews and Co., illustrating concentric armoured mains, with branches to brackets, pendants and standards fitted throughout with concentric switches and fuses. The wiring has a very neat appearance, and for flexibles, exterior braided copper is used, the inner conductor being a fine copper strand inside. We inspected these exhibits during the morning, and exhibits by other makers were added before the time of the lecture.

Manchester.—At the Manchester City Council the report (an abstract of which we give elsewhere) was before the meeting. Alderman Sir J. J. Harwood proposed the adoption of the report. Since 1881 the committee had visited every important public installation in England. The result showed that the utmost care was necessary, and the committee suggested, with a view to avoid all mistakes, that the best professsional advice should be sought to draw up a scheme for the sanction of the Council. The committee sought authority to select three or four electricians of reputation, to give them 100 guineas each, and ask them to give in return the benefit of their knowledge and experience by saying which was the best mode of procedure, the best kind of machinery to be employed in carrying out the order. Such a course must present itself to the Council as being most desirable. The £400 or £500 expended in the initial stage would be money wisely spent. It would be only a small sum compared with the loss which would follow if in the initial stage they made any serious mistakes. Under any circumstances he thought it was going to cost them a good deal of money. At Bradford the price was 5d. a unit, but there was a loss. At Brighton it was 8d. a unit, but there was no dividend. At 6d. a unit it would be equivalent to gas at 5s., and the plant per light was, he said, three times as costly. No meter that could be relied upon for measuring the electric light could be got for less than £9. The electric light boom, he thought, had been a great deception. The great proportion of the money invested in it had been wasted on scientists, patentees, and promoters. Under these circumstances, the Gas Committee had thought it right to hold their hands, and not rush hastily into the undertaking. The electric light could only be used as a luxury, and under exceptional conditions, and how far the whole of the citizens would be justified in going into an undertaking for the few who could afford to pay for it was a matter in which the Gas Committee had, in his judgment, wisely hesitated to decide. They would proceed with it at the wish of the Council, on the distinct understanding that they were not to act rashly, but were allowed to act with every precaution. He therefore moved that the report be adopted, and the committee be empowered to act with perfect freedom in their further proceedings. The report was agreed to.

An Electrical Elysium.—Mr. E. H. Johnson, in one of the New York dailies, gives a long and glowing account of what electricity may be expected to do during the next century in rendering our cities clean and bright, and our homes automatically supplied. He summarises the necessities by reducing the calls upon electricity to four—viz., communication, light, power, and heat—and gives his own experience thus: "A man who has warmed his own den, cooked his own steak, mulled his own wine, brewed his own toddy, aye, and warmed his own bath solely by the aid of heat electrically generated, and who has farther measured the quantity and computed the value of the electric current required in the operation, is not one to whom it can be safely said that electric heat has no future." He concludes an interesting popular exposition of his views by the following peroration in the style of "Looking Backwards": "We have put all heavy traffic in our towns in clean, dry iron tubes at a depth sufficient to be clear of all surface considerations. We have paved our roads with asphalte surfaces like unto a mirror. We have given eternal freedom to the draught and car horses, and have installed self-propelling noiseless carriages. We have shipped our steam and gas engines to China and the Congo, and our gas reservoirs to the oilfields, and our stoves to the missionaries. We have melted up our copper boilers and drawn the metal into conductors for our electric service, and have filled our hot-water pipes with cooling zephyrs laden with the odours of Araby. Our linen is whitened as of snow under umbrageous foliage with no contamination of drifting atomic carbon. Our streets are lined with foliage whose sere and yellow leaf comes not out of season but only as nature calls. Our pavements are swept clean and our horses, now our companions and not our servants, tread daintily and comfortably in shoes of elastic quality and no longer on rigid steel. Our food is now prepared by the *chef* of the caterer, and is cooked by the 'lady of the house.' The *débris* of the after-meal is reduced to ash in our electric furnace, and garbage has become an unknown quantity. Our chimneys are now mere ventilating shafts, and the sportive swallow resides there in comfort and safety. Our drawing-rooms are alive with colour without odour, with the glowing log which is yet not consumed and giveth forth no ash to vex the soul of our loving spouse. Our bath is tempered by our auto-electro heater, and set to any degree of temperature that may be found most soothing to the glowing, healthful body of our arcadian citizen. To the end that serious thought may be given to the subject herein discussed, the writer, not unmindful of his business repute, respectfully submits that he is ready and willing to place his personal time, experience, and reputation at the service of capital in the practical and commercial consummation of any one or all of the applications of electricity herein suggested." The London County Council ought to secure a genius of this order.

Dierman Dynamo. — The Dierman dynamo, a Belgian type, is characterised by the employment of a field magnet formed of a single horizontal core, wound with a suitable coil of wire, and with pole-pieces at its two extremities which extend upwards and embrace the armature. This arrangement is stated to give the greatest simplicity of construction, and to furnish, in spite of the suppression of the yoke, the magnetic intensity of the horseshoe form. The armature core is built up of a series of thin sheet-iron discs, insulated from each other by paper, cotton, or mica. These discs are drawn together by a set of bolts passing through the whole, but insulated by an insulating sleeve, and by a conical piece at the head. The nut presses against a disc of fibre. The two pole-pieces rest upon a single base-plate, on which are mounted the two standards for the armature bearings; the pole-pieces are connected together at the top by a piece of copper, which seems to protect the armature. The armature is wound with a square wire, "rendered supple by lamination in the direction of bending." The coils are connected to a commutator formed of bronze, furnished with shoulders pierced with square holes to receive the wire. According to the inventor, this dynamo presents the following advantages: The use of a single coil forming the field magnet; combination of this single horizontal coil, with two vertical pole-pieces with extensions above the core, so that the whole forms a horseshoe magnet; construction of an armature of discs of thin sheet iron insulated from each other; tightening up of these discs by means of bolts perfectly insulated; use of a single base-plate on which are fixed the pole-pieces by the intermediary of a piece of zinc. The following are particulars of a dynamo on this system, giving 350 amperes at 110 volts:

Speed of rotation.......................... ..	600 revolutions
Weight of copper armature	154lb.
,, ,, field magnet	396lb.
,, ,, armature per watt...	1·82 gramme
,, ,, magnet per watt ...	4·72 ,,
Weight of iron in armature	330 lb.
,, ,, magnet	682 ,,
,, frame	3,300 ,,
Exciting current	7 amperes.
Ampere-turns, thin wire	1,800
,, thick wire	2
Efficiency (com'l), 10-kilowatt dynamo.	85 per cent.
,, ,, 15 ,, ,, ...	86 ,,
,, ,, 20 ,, ,, ...	87 ,,
,, ,, 40 ,, ,, ...	88 ,,
,, ,, 75 ,, ,, ...	90 ,,

Seventeen installations of various sizes have, says the *Bulletin International de l'Electricité*, been carried out with n Belgium during the past year.

A NOTE ON ECONOMY IN CONDUCTORS.

BY HAMILTON KILGOUR.

In designing a system of mains for distributing electrical energy, it is sometimes assumed that when the current density for one pair of feeders is determined upon, that in any other pair is settled by the principle of Ohm's law.

This, of course, assumes that the load diagrams for all the feeders are similar; and it is implied that the pressure at the feeding points can be kept constant by varying the pressure at the station omnibus bars in proportion to the output without the necessity of having regulators in the feeding mains.

Without entering into any discussion as to the probability of a case of this kind occurring in practice, it may be worth while to investigate what the current density should be in the pair of feeders to be settled first.

It is clear that we cannot fix the current density for any pair of feeders by simply considering its cost and the power to be distributed by it, regardless of all the other feeders.

The problem is one of those best solved graphically in practical cases on account of the variation of quantities usually treated as constants in theoretical investigations of this kind, but, for the sake of simplicity, it will be assumed in this article that the cost per mile of a conductor of cross-sectional area A square inches, laid complete, can be represented by the expression $(\mu + \nu \mathrm{A})$ pounds, where μ and ν are constants depending on the insulation, the type of conduit, the value of labour, etc.

On the assumption that the load diagrams for all pairs of feeders are similar, and that the fall in volts at every instant is to be the same in each, we must have

$$\frac{\mathrm{D}_m}{\mathrm{D}_n} = \frac{a_n}{a_m},$$

where

D_m = maximum current density in amperes per square inch in pair of feeders No. m;

D_n = Do. in feeders No. n;

a_m = length in miles of feeders No. m;

a_n = Do. of feeders No. n;

that is, the current densities in the feeders are simply inversely as their lengths.

Let us suppose that in the case we are to consider there are n pairs of feeders, and that we know the length of each and the maximum power to be distributed by it. We must know, further, the ratio of the square root of the mean square of the current density to the maximum current density from a year's load diagram of a similar district, the values of the constants μ and ν for the system of mains to be put down, the pressure in volts to be maintained at the feeding points, the number of hours of working per annum, the *cost* of a Board of Trade unit, and the percentage annual charges for depreciation, repairs, and interest on the mains.

We have given, then, the following data:

Pair of feeders No.	Length of single feeder in miles.	Maximum power to be delivered by pair of feeders in kilowatts.
1	a_1	P_1
2	a_2	P_2
⋮	⋮	⋮
m	a_m	P_m
⋮	⋮	⋮
⋮	⋮	⋮
n	a_n	P_n

V = pressure at feeding points in volts;

λ = ratio of square root of mean square of current density to maximum current density;

= number of hours of working per annum;

B = cost price of a Board of Trade unit in pence;

i = sum of the rates of interest, depreciation, etc., on mains laid complete;

together with the values of the constants μ and ν.

From the foregoing data we have to determine the maximum current density in pair of feeders No. 1.

Let D_1 = maximum current density in pair of feeders No. 1 in amperes per square inch,

d_1 = square root of mean square of current density in ditto,

so that $d_1 = \lambda \mathrm{D}_1$.

Considering, then, any pair of feeders, say No. m, let

C_m = current in amperes at any instant;

A_m = cross-sectional area of copper in conductor in square inches;

D_m = maximum current density in amperes per square inch;

R_m = resistance of going and return feeders in ohms;

W_m = annual waste of energy in pair of feeders in Board of Trade units;

r = resistance of two miles of conductor of one square inch cross-sectional area of copper.

Then $(\mathrm{C}_m)\max = 1{,}000\,\dfrac{\mathrm{P}_m}{\mathrm{V}}$

$$\mathrm{D}_m = \frac{a_1}{a_m}\,\mathrm{D}_1 = \frac{a_1}{a_m}\cdot\frac{d_1}{\lambda}$$

$$\mathrm{A}_m = (\mathrm{C}_m)\max \div \mathrm{D}_m$$

$$= \frac{1{,}000\,\lambda}{\mathrm{V}\,d_1}\cdot\frac{a_m}{a_1}\,\mathrm{P}_m$$

$$\mathrm{R}_m = \frac{a_m}{\mathrm{A}_m}\,r$$

and $\sqrt{}(\text{mean}\,\mathrm{C}_m{}^2) = \dfrac{a_1}{a_m}\,\mathrm{A}_m\,d_1$

Hence $\mathrm{W}_m = \dfrac{\mathrm{N}}{1{,}000}\left(\dfrac{a_1}{a_m}\,\mathrm{A}_m\,d_1\right)^2\cdot\dfrac{a_m}{\mathrm{A}_m}\,r$

$$\mathrm{W}_m = \frac{\mathrm{N}\,r\,\lambda\,d_1 a_1}{\mathrm{V}}\,\mathrm{P}_m.$$

The value of this wasted energy, W_m, is

$$\frac{\mathrm{W}_m\,\mathrm{B}}{240}\text{pounds} = \frac{\mathrm{N\,B}\,r\,\lambda\,a_1}{240\,\mathrm{V}}\cdot\mathrm{P}_m\cdot d_1\text{ pounds.}$$

The cost in pounds of the pair of feeders laid complete is

$$a_m(\mu + \nu\,\mathrm{A}_m) = \mu\,a_m + \frac{1{,}000\,\lambda\,\nu}{\mathrm{V}\,a_1}\cdot a_m{}^2\,\mathrm{P}_m\cdot\frac{1}{d_1},$$

and the annual expenditure on repairs, depreciation, etc., will therefore be

$$\mu\,i\,.\,a_m + \frac{1{,}000\,\lambda\,\nu\,i}{\mathrm{V}\,a_1}\cdot a_m{}^2\,\mathrm{P}_m\cdot\frac{1}{d_1}.$$

The total annual expenditure in pounds on this pair of feeders is then

$$\frac{1{,}000\,\lambda\,\nu\,i}{\mathrm{V}\,a_1}\cdot a_m{}^2\,\mathrm{P}_m\cdot\frac{1}{d_1} + \mu\,i\,.\,a_m + \frac{\mathrm{N\,B}\,r\,\lambda\,a_1}{240\,\mathrm{V}}\cdot\mathrm{P}_m\cdot d_1.$$

If U = total annual expenditure in pounds on all the feeders

$$\mathrm{U} = \frac{1{,}000\,\lambda\,\nu\,i}{\mathrm{V}\,a_1}\sum_1^n(a_m{}^2\,\mathrm{P}_m)\cdot\frac{1}{d_1} + \mu\,i\sum_1^n(a_m) + \frac{\mathrm{N\,B}\,r\,\lambda\,a_1}{240\,\mathrm{V}}$$

$\sum\limits_1^n(\mathrm{P}_m)\,.\,d_1$. Whence the most economical maximum current density to employ in pair of feeders No. 1, or $\dfrac{1}{\lambda}$th of the value of d_1, which makes V a minimum, is

$$\mathrm{D}_1 = \frac{240{,}000\,\nu\,i}{\mathrm{N\,B}\,r\,\lambda\,a_1{}^2}\;\frac{\sum\limits_1^n(a_m{}^2\,\mathrm{P}_m)}{\sum\limits_1^n(\mathrm{P}_m)}\;.\;.\quad(\mathrm{A})$$

Now, if $\mathrm{D'}_1$ = most economical current density to employ in pair of feeders No. 1, determined by considering that pair of feeders alone;

$$\mathrm{D'}_1 = \frac{240{,}000\,\nu\,i}{\mathrm{N\,B}\,r\,\lambda\,a_1{}^2}\;\frac{a_1{}^2\,\mathrm{P}_1}{\mathrm{P}_1}\text{, as is easily seen.}$$

Then $\dfrac{\mathrm{D}_1}{\mathrm{D'}_1} = \dfrac{\sum\limits_1^n(a_m{}^2\;\mathrm{P}_m)}{a_1{}^2\;\sum\limits_1^n(\mathrm{P}_m)}$, and similarly for any other pair of feeders, No. m

$$\frac{\mathrm{D}_m}{\mathrm{D'}_m} = \frac{\sum\limits_1^n(a_m{}^2\;\mathrm{P}_m)}{a_m{}^2\;\sum\limits_1^n(\mathrm{P}_m)}.$$

To take an example, suppose we have six pairs of feeders, as under:

No. of pairs of feeders.	a miles.	P kilowatts.
1	1	30
2	1·2	40
3	1·5	20
4	1·6	15
5	1·7	25
6	1·9	10

So that $\sum_{1}^{n} (P_m) = 140$

$$\sum_{1}^{n} (a_m^2 P_m) = 279{\cdot}35.$$

Then, if $E_m = \frac{D_m}{D'_m}$ we have

Pair of feeders. No.	E
1	2·00
2	1·39
3	0·89
4	0·78
5	0·69
6	0·55

From this example we see that a very considerable error is probable, if we seek to determine the proper current density to employ by considering one pair of feeders alone, and that in any case in which the assumptions made in this article are permissible, the maximum current density for one pair of feeders should be worked out by formula (A), and the maximum current densities in the other pairs of feeders deduced from the result obtained.

It must be observed, however, that the conditions of practical working do not require that the pressure at every pair of feeding points shall be maintained absolutely constant to the pressure V, but that this pressure shall not be departed from by more than a small percentage. The maximum current density, D_m, found as above, may therefore at least be altered to be more nearly D'_m, with the condition that the gain or loss of pressure—due to this change of maximum current density—does not exceed the percentage of V fixed upon as permissible.

The consideration as to whether a still more economical solution can be found of the problem of determining the maximum current densities in all the feeders, so that the total annual expenditure on them may be a minimum when a small variation of pressure from V is allowed at each pair of feeding points, must be postponed to another note.

NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.[*]

BY W. B. ESSON, MEMBER.

Though comparisons have frequently been made of the capabilities of machines having two poles, and those having a greater number, I am not aware that the design of multipolar dynamos has yet received systematic treatment in any communication, or that a very satisfactory basis for comparison of the two types has up to the present been suggested. A perusal of the notes scattered about in technical journals, *Proceedings* of societies, and text-books, shows that the ideas on this subject are of the vaguest character, their expression having a most uncertain tone, and generally manifesting some erroneous notion. It is with a view of clearing the ground a little, and inducing some expression of correct ideas from members present, that these notes are brought before the Institution.

1. PREVENTION OF SPARKING IN MACHINES GENERALLY.

In the paper which I submitted for your consideration 12 months ago, attention was directed to certain empirical formulæ relating to the armature loads for direct-current machines. From the data furnished by a large number of examples, some of which were given in the paper, an expression for the load which could be safely carried by armatures without causing sparking was obtained; this expression, though admittedly of an arbitrary character, having been proved by my own experience, and that of my colleagues, to have been of some service. In that paper the term "ampere-hours" was employed to denote the product of the number of conductors on the exterior of the armature and the current carried by each, and I am afraid this may have led to some confusion; at least, so it appears from the discussion. In order that there shall be no misunderstanding in the present case, I shall call this product, quite irrespectively of the number of poles, the volume of current carried. The volume is therefore the total current flowing parallel to the armature shaft, independently of direction and whatever the number of poles, and it is obtained by multiplying the conductors on the exterior of the armature by the current flowing in each; or, considering the exterior winding as a copper cylinder, it is the total current flowing in it parallel to the axis.

In his paper on "Armature Reactions," read here last year, Mr. Swinburne had worked out the limiting load from a theoretical point of view, and those who were present will remember that to obtain the results given in his paper the author assumed that the brushes were placed almost close to the polar tips. So far as the practical consideration of the subject goes, it matters little, I think, whether this is strictly accurate or not; because, while moving the brushes back from the tips increases the ampere-turns producing the cross field, the magnetic resistance of the cross circuit is at the same time increased, due to the interposition of an increased air gap. For the moment, however, it will be assumed that the brushes are somewhere near the pole-tips—in their vicinity, let us say—and that the only conductors concerned in producing the cross field are those covered by the pole-pieces. This is sufficiently near the truth for our purpose. Under these circumstances the magnetising force in ampere-turns producing a cross field is, of course, $\frac{v\,\phi}{360}$, where v is the volume, and ϕ the angle embraced by each pole-piece in degrees. Call l the length of the air gap, measured from the surface of the armature core to the polar surface, and I the induction per square centimetre which would be produced in the gap due to the field magnets alone. When a current flows in the armature the field is weakened at the pole-tips nearer the brushes, and strengthened at those farther from them. Imagine that the armature is loaded so that the forward induction under the nearer pole-tips is just balanced by the cross-induction, and we have $\frac{v\,\phi}{360} = 2\,l \times {\cdot}8\,\mathrm{I}$, assuming that the components of the cross circuit, other than the air gap, have no resistance. According to this equation, with a value $v = \frac{576\,l\,\mathrm{I}}{\phi}$,[*] the forward and cross induction at the pole-tips would be equal, the field would be *nil* at the brushes, and, the machine being unstable, any increase of current would at once cause great sparking.

The above expression gives what might be called the theoretical load limit, on the assumption that no field is required for reversing the current in the sections as they pass the brushes, but it need scarcely be pointed out that in practice the volume is always much under what would be given by the formula. In the nature of things, one expects in the dynamos of different makers a considerable variation in the relation which the actual load bears to the limit above indicated, and such differences undoubtedly exist; but while one finds, on examining a large number of machines, several under, in few cases are there any having for v a greater value than half that given by the equation. This large margin must be considered in the light of a safety factor, for it would be folly to build machines the commutators of which would be liable to ruin by an occasional increase of current over the normal. No one expects machines to stand, in continuous working, a current of 50 per cent. over their normal output, for the rise in temperature would then be excessive; but, from the sparking point of view, this increase in a well-designed machine ought to make but little difference to it. Generally, the relation existing between the volume, gap dimensions, and induction in the best machines is expressed approximately by the equation,

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[*] Paper read before the Institution of Electrical Engineers, April 9, 1889.

[*] I have pointed out to Mr. Swinburne that the equations, $A = \frac{10\,b\,g\,B_a}{\theta^2\,r}$ and $A_2 = \frac{10\,B_a\,r\,R\,l}{w^2}$, which he gave last year on p. 266 of his reply, ought to be $A = \frac{5\,b\,g\,B_a}{\theta^2\,r}$ and $A_2 = \frac{20\,B_a\,r\,R\,l}{w^2}$ respectively. In looking over his paper and reply, Mr. Swinburne finds other slips, which he will probably correct as discussion on the present paper proceeds.—W. B. E.

$$v = \frac{288\,l\,I}{\phi} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

which gives, I consider, a very good rule for use in practical work. According to this, the working volume has about half the value expressing the absolute limit, this relation indicating the margin of safe working dictated by practice and experience. The formula expresses, in fact, an empirical relation which has a certain degree of flexibility. But with such a large margin it will be readily perceived that the strict accuracy of our assumption about the position of the brushes is of trifling importance, as is also our assuming that the whole of the magnetising force of the cross field is spent in the air gap.

It is easy to translate the above expression into the form I previously used for cylinder armatures. Call r the radial depth of the armature core, w the width of the pole-piece, and I_2 the induction in the core. The induction, I, in the gap is $\frac{2rI_2}{w}$; and substituting for I its value, we have

$$v = \frac{576\,r\,I_2\,l}{w\,\phi} \quad . \quad . \quad . \quad (2)$$

Taking the induction in the armature core at from 17,000 to 18,000 C.G.S. per square centimetre, and inserting an average value of ϕ, we get for bi-polar Gramme-wound machines the expression,

$$v = \frac{r\,l\,85{,}000}{w} \quad . \quad . \quad . \quad . \quad (3)$$

which I had used for some time, and which was given in my last year's paper. This is only a rough approximation, for, as Mr. Swinburne has pointed out, to be quite accurate the angle should appear in the denominator as in (1) and (2). The simplest form the expression can take is given in (1). This contains nothing but the length of the air gap, the induction in it, and the angle of the pole-piece. It will be observed that it takes no notice of the diameter of the armature or of the number of poles. So far as the sparking limit is concerned, it gives a rule which may be employed in designing machines of any size and with any number of poles.

2. The Relation of v to the Diameter of the Armature.

But besides taking care that the armature load does not approach the sparking limit, we must provide ample surface for getting rid of the heat generated in the conductors. The first thing to be settled in designing a new machine is what this amount of heat shall be; or, in other words, we must fix the ratio which the energy appearing at the terminals shall bear to the total electrical energy produced. Having settled this, sufficient radiating surface must be allowed to prevent too great a rise in temperature—a point to which due consideration has already been given.

The principal factors which determine the relation of the volume to the diameter of the armature are efficiency and temperature. It will be seen that the equation (1) gives no direct information respecting the diameter for a given volume, and as long as I, l, and ϕ remain unchanged, the tendency to sparking would be the same whatever the diameter. But it is not so with the heat generated or the temperature rise, for assuming v and l to be related as shown, the smaller the diameter, the greater would be the temperature. To carry a given volume we must have, consistent with the waste of power permissible, a certain section of copper; and this copper should be disposed so that a cooling surface is provided sufficient to keep the rise in temperature within the specified limit, while the gap, being of sufficient length to prevent sparking, should have only the dimensions necessary for accommodating the conductors and allowing of proper clearance.

Through the kindness of members of the Institution and others, who have liberally supplied me with figures, I have been able to ascertain the nature of the relation between the diameter and volume existing in all the best-known machines from the smallest to the largest sizes. The figures refer to both cylinder and drum wound armatures, and include machines with two, four, six, and eight poles. Though I am not at liberty to publish the data in full, the general results are given. There is not so much agreement between the dynamos of different makers in respect to this relation as might have been expected, and for v we have all kinds of values, ranging from 200 to 1,000 times the diameter of the armature in centimetres. If full advantage of the length of the air gap were taken, and the thickest possible conductor used in each case, the diameter, to give a uniform temperature for all sizes, would be about proportional to the square root of the volume, but there are several reasons why this proportion should not obtain in practice. With this relation the ratio of the stray to the useful field would increase with the diameter, thus entailing an extravagant expenditure of energy in producing the requisite gap induction. Again, while the total field through the armature would increase simply as the diameter, the volume carried would increase as the square of the diameter, this being at variance with the well-established rule that the total field through the armature increases rather than diminishes relatively to the volume as the size is increased. It will be understood, of course, that precisely the same result is arrived at whether we consider the volume fixed and endeavour to find the best diameter, or consider the diameter fixed and seek for the best volume. It is simply a question of obtaining the most economical construction, having regard to cost of materials, efficiency, prevention of sparking, and temperature limit, though the figures at my disposal show estimates of the relative values of these several factors to be by no means uniform.

Though the relation lacks definiteness to some extent, I find in the data of a large number of machines indications sufficiently pronounced to justify us in regarding the volume carried by the armatures of two-pole dynamos as proportional to the diameter for all sizes. In designing cylinder machines the value of v may be taken as 400 times the diameter of the armature in centimetres, while for drum armatures the volume is obtained by multiplying the diameter by 600.* The cylinder armature has for a given volume a larger diameter, because of the influence of the interior wires. These being heaped inside to one and a half or twice the depth of the exterior winding, also being longer, a larger diameter is required for a given volume, both from efficiency and temperature considerations. Necessarily, the relations here given are not of a hard-and-fast character, and may be varied considerably. But whatever the proportion adopted, it is absolutely essential that the sparking limit already considered be not too closely approached.

In machines having four and six poles the same average relation between the volume and diameter holds in practice for both cylinders and drums. In the calculations which follow these figures will therefore be adopted.

3. Output of Direct-Current Armatures.

If we call N the total number of lines of force entering the armature from all the poles, however many, and n the number of revolutions per second, the average E.M.F. generated to each conductor is, of course, $N\,n\,10^{-8}$. If C be the total current flowing, each conductor will carry with the sections coupled in the ordinary way $\frac{C}{p}$ amperes, p being the number of poles. The electrical work due to each conductor is $\frac{C}{p} \times \frac{N\,n}{10^8}$; and the total work $\frac{wC}{p} \times \frac{N\,n}{10^8}$, where w is the number of conductors, counted all round the exterior of the armature. The quantity $\frac{wC}{p}$ is what we have called the volume, and we get for the total electrical output in watts the expression

$$W = N\,n\,v\,10^{-8} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

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* In my last paper the number given was 570. This I now amend as above.—W. B. E.

which is quite independent of the manner of coupling up the armature sections. It will be evident, I think, that with the same relation existing between v and d for two, four, and six poles, the output of an armature of given diameter and length, running at the same speed, is quite independent of the number of poles. It matters not whether N be furnished by two poles only, or by four poles of half the angular width, provided its value remains unaltered.

The volume, then, may be expressed in terms of the diameter. The quantity N may be expressed in terms of the diameter × length of the armature. Taking an induction of 5,000 C.G.S. units per square centimetre in the air gap—a very usual figure—and assuming that the fraction of the armature circumference covered by the pole-pieces = $2 \cdot 25\, d$, we get, calling L the length of the armature in centimetres, $11{,}250\, d\, L$ as the total number of lines of force entering the core. Call this, in round numbers, $12{,}000\, d\, L$. Substituting for N and v their values, the output becomes for cylinder armatures

$$W = \cdot 048\, d^2 L\, n \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and for drum armatures

$$W = \cdot 072\, d^2 L\, n \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This applies to all direct-current machines, whether bi-polar or multipolar; though it will be understood, of course, that the induction in the gap may be greater or less than what has been assumed. In that case the coefficients ·048 and ·072 would be altered, without changing, however, the form of the expression.

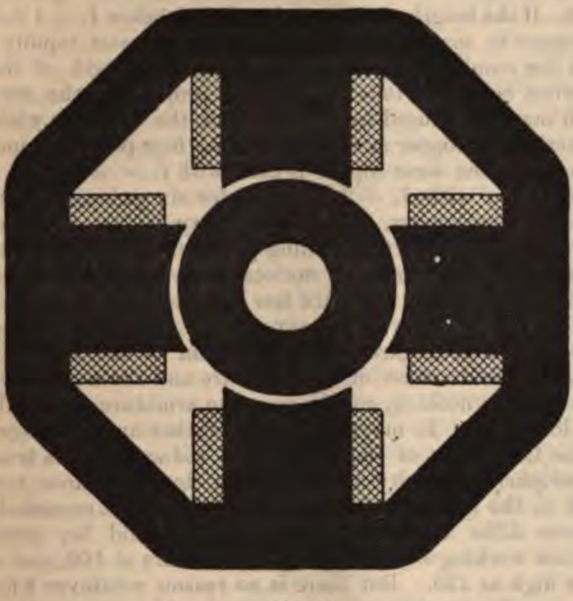

Fig. 1.

4. Output of Alternating-Current Armatures.

The armature loads for alternators, though producing a cross-magnetisation, as in direct-current machines, raise no considerations, of course, as regards sparking. But on account of the greater proximity of the poles, and the greater stray field resulting, it is desirable to make the layer of copper on the armature core as thin, and the air gaps as short, as possible. As a consequence, probably, of the increased ratio of stray to useful field, the induction is less in the gaps of alternating than in those of direct-current machines. Here it will be assumed that the virtual induction is 4,000 C.G.S. units per square centimetre, meaning that this represents the induction to which the resultant E.M.F. is due. The impressed E.M.F. is greater than the resultant, and the induction due to the field magnets alone is greater than 4,000; but what I am dealing with is the field resulting from the interaction of the magnet and armature fields: it is the field to which the resultant E.M.F. = C R is due, this and the current being coincident in phase. Usually the poles cover a fraction of the circumference = $1 \cdot 5\, d$, the value of N for alternators being then $6{,}000\, d\, L$. About half the circumference being covered with wire, under usual conditions of temperature and efficiency we have for v a mean value of 400, which gives for the product of mean resultant E.M.F. and mean current = $\cdot 024\, d^2\, L\, n$. In some cases, as in the Westinghouse machine, the conductors cover considerably more than half the circumference, and v is therefore greater. But here, on account of the differential effect produced on the separate wires of the same section, the added turns have nothing like a proportionally increased value, and the expression will give approximately the value of the product of mean resultant E.M.F. and mean current, even in these machines. Assuming that the E.M.F. is a sine function of the time, to get the watts we must multiply by $\frac{\pi^2}{8}$, which gives us, therefore, as the output of the alternator

$$W = \cdot 0296\, d^2 L\, n \quad . \quad . \quad . \quad . \quad . \quad (7)$$

or rather over 40 per cent. of the work done by a drum-wound direct-current machine having an armature of the same external dimensions. Some comparisons have been made of the output of direct and alternating machines of the same weight, but these, in the nature of things, must be misleading. The two types are quite unlike in their proportions, as Figs. 1 and 2 show, and no one would think of making them the same. Fig. 1 represents the magnetic system of a four-pole direct and Fig. 2 that of a 12-pole alternating machine of the same output; and while it will be observed that the iron parts—core and yoke rings—are much heavier in the former, it will be noticed that the copper in the magnet coils is much heavier in the latter. In fact, though the iron in the alternator is only 55 per cent. of that in the direct-current machine, the copper required is no less than 250 per cent. It is difficult, then, to understand what useful purpose is served by comparisons such as I have alluded to.

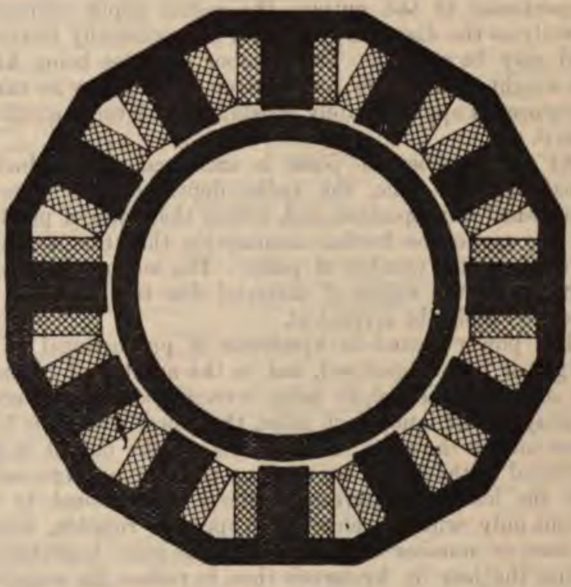

Fig. 2.

5. Relation of Air Gap to Diameter of Armature and Number of Poles in Direct-Current Machines.

Having established the proportionality of the volume and diameter, it is easy to find the relation which must exist between the diameter and length of air gap for any particular angle of embrace in order that sparking may not occur. I need not take up time ringing changes on the several equations, as to obtain the relation now referred to, all that has to be done is to substitute for v in (1) its value in terms of the diameter accordingly as the winding is of the cylinder or drum type, and find the connection between l and d. Preserving the same safety factor throughout, it will be found that two-pole dynamos with a mean gap induction of 5,000 C.G.S. units per square centimetre, and pole-pieces embracing an angle of 130deg., must have—the volume being related to the diameter as described—a gap of not less than $\cdot 036\, d$ if cylinder-wound, or $\cdot 054$ if drum-wound. As will have been observed, the air gap may diminish as the induction is increased, or as the volume is reduced.

But, as is also seen from the equation, the gap required for any particular volume is proportional to the angle of embrace, and if we substitute for two poles a greater number of correspondingly less angular width, working with an increased diameter and volume without a proportionally increased gap is made possible. This is where the advantage of the four, six, or even eight pole machine comes in. Keeping to two poles, increasing the diameter requires either a proportional increase in the gap, whether the space is required for the conductors and clearance or not, or an increased induction, or a diminished polar angle, or a combination of these. In either case, the magnetising force spent in the gap is increased; and, other things remaining the same, obviously it would be of some advantage to adopt a construction which, while producing no greater tendency to sparking, would admit of the air gap being reduced until its length was just sufficient to accommodate the conductors and allow of the necessary clearance. The work done by an armature of given external dimensions we have seen to be quite independent of the number of poles, and the choice of this number can only be a question, therefore, of structural working and economy.

6. Dimensions of the Armature.

It has been observed that the output of an armature is proportional to d^2 L; and the induction being the same, the weight of the core for a given number of poles must be proportional to the output, the radial depth increasing directly as the diameter, so that a proportionally increased field may be carried. The number of poles being fixed, the weight of the core for a given output may be taken, therefore, as approximately constant, whatever the ratio of L to d.

As the number of poles is increased, the induction remaining the same, the radial depth of the core is diminished in proportion, and, within the limits of practice, we may make the further assumption that the weight is inversely as the number of poles. The money value of a reduction in the weight of material due to increasing the poles can easily be arrived at.

The power wasted in hysteresis is proportional to the weight of iron magnetised, and to the number of reversals per second. The weight being inversely and the reversals directly as the number of poles, the power wasted is for a given output the same; furthermore, as the output is proportional to the speed, we may say that for a given induction the loss in hysteresis is about proportional to the output only, without reference to speed of rotation, weight of core, or number of poles. If it be more important to reduce the loss by hysteresis than to reduce the weight of material, it can, of course, be done. It is a point for the designer to consider.

So much for the core; let us now consider the copper part. Taking Gramme-wound armatures having an interior opening equal to ·66, or two-thirds of the core diameter, it is found—the output, speed, and temperature being predetermined—that the ratio of L to d may vary through a considerable range without making any great difference in the weight of copper or efficiency. For instance, the most efficient relation being $L = \frac{d}{3}$, it may be varied on the one hand till $L = d$, or on the other till $L = \frac{d}{6}$, without increasing the copper by more than about 10 per cent. Of course, the watts wasted in the armature are correspondingly increased, but within the limits of the large variation mentioned the reduction in the electrical efficiency of the machine is under one-half per cent. In two-pole machines L varies from ·5 to 1·5 d, the normal relation being about $L = d$. As has been seen, the gap has to be increased in proportion to the diameter, unless a greater number of poles be employed, and the disadvantage of an increased magnetising force would, in machines with only two poles, counterbalance the slight advantage of getting the armature dimensions nearer the best proportion. When the poles are increased, however, the gap may remain fixed, and if the radial depth of the core be correspondingly diminished, the proportions for least copper and higher efficiency are altered. Thus in a four-pole Gramme we can work from $L = \frac{d}{3}$ up to $L = \frac{d}{12}$ without a greater variation than 10 per cent. in the weight of copper. Observe, this is a question differing altogether from the one which was considered in my former paper. In that case the length and radial depth of the armature over the winding were fixed, the problem then being to find the best relation of copper to iron. Here both radial depth and length of core alter, also the peripheral velocity, though the revolutions per minute remain the same. Why the velocity is allowed to alter will be immediately apparent; I only show at the moment that the dimensions of the armature may have their relations altered considerably without making any considerable difference to the weight of copper or efficiency.

To drum-wound armatures precisely the same reasoning applies. Here, speed and temperature being fixed as before, the best proportion for two-pole machines is about $L = 3·3\,d$; but because of the distance between the bearings with such a relation would necessitate being inconveniently great, we rarely find $L = 2\,d$ exceeded. The latter requires about 5 per cent. more copper than the former; while for the usual proportion, $L = 1·5\,d$, 12½ per cent. more is required than for $L = 3·3\,d$. The variation which can be made without overstepping the limits of economy has a smaller range in drum than in cylinder machines, owing to the greater relative importance of the end wires, because of their greater length. If the length of the core is reduced below $L = 1·5\,d$, the copper in machines with two poles increases rapidly; but if the number of poles be increased, the length of the end wires being shortened nearly in proportion, the core length may be reduced to a fraction of the diameter without sacrifice of copper or efficiency. In a four-pole machine, for instance, the same copper is used with $L = ·5\,d$ as in a two-pole one with $L = 2\,d$; while for six poles, without increasing the copper, the relation may be as small as $L = ·25\,d$. The effect of adding poles when the diameter is relatively great is not so noticeable in Gramme-wound machines, as the end wires are less important.

All the above facts go to prove that if there is anything to be gained, as regards the production of the field, by increasing the diameter of the armature and the number of poles, there is nothing, considering the armature by itself, to be lost by it. It may, in fact, be rather an advantage, because the weight of the iron core is reduced. It is true the peripheral velocity is increased; but this does not matter in the least, provided a certain limit is not exceeded. Opinions differ as to what the limit should be, some machines working at 50ft. per second, others at 100, and a few as high as 125. But there is no reason whatever why any properly constructed armature should not run at a periphery speed of 100ft. per second; and provided this velocity is not exceeded, any advantage which may be obtained by a relatively large armature and increased number of poles should be secured.

7. Dimensions of the Field Magnets.

It will be apparent, from the foregoing considerations, that the employment of two, or more than two poles for direct-current machines of moderate dimensions, resolves itself mainly into a deliberation regarding the most economical shape to give to the field magnets. As regards the armature, considered by itself, we may say that the choice of dimensions is mostly a matter of convenience, seeing that the amount of copper required and efficiency are for a given output practically unaltered by variations in this respect, while the reduction in the weight of the core due to an increased number of poles is to some extent compensated by the extra expense of larger plates and increased weight of the armature supports. Again, the cost of labour is increased by the larger diameter; but, everything being taken into account, considerations respecting the armature do not influence the design to a very great extent. One thing in favour of increasing the poles, as far as the armature is concerned, must, however, be remembered, and that is the reduction, consequent on a smaller conductor being used, of the losses arising from parasitic currents. We now turn our attention to the magnets.

I have said that for the prevention of sparking it is necessary that, the induction per square centimetre remaining the same, the air gap increases proportionally to the diameter, whether the space is necessary for conductors and clearance or not, but that the coefficient by which the diameter has to be multiplied to give the length of the gap necessary to prevent sparking diminishes directly as the pole angle. In comparing the magnetic system of a four or six pole machine with that of a two-pole one, it is necessary to adopt dimensions for the armature in accordance with the considerations already mentioned; hence, if the two-pole armature had a length of core equal to one and a half times its diameter, in a four-pole one the length should be about half the diameter. The diagrams, Figs. 3 and 4, show the cross-sections of two such machines. The diameter of the four-pole armature is 1·4, and its length ·5 times that of the two-pole one, consequently both machines give the same output. The weight of the two horseshoe magnets in the four-pole machine comes to 56 per cent. of the weight of the single horseshoe magnet, which indicates in this particular case a considerable saving in wrought iron. In taking the copper weight it is necessary to bear in mind that this does not vary simply as the length of the wire if the machines are of the same efficiency, but as the square of the length; so in this particular comparison the copper on the two horseshoes would be, roughly, 30 per cent. more than on the single horseshoe, assuming the length of the air gaps to be the same. Now, if it were possible to reduce the gaps by 12 per cent. or so, the copper weight would be similar in both machines, and we should have credit for a certain amount of iron saved in the construction of the four-pole one, which could be balanced against the increased expenditure for labour. If the gap can be reduced by more than 12 per cent., always retaining the depth of the winding the same, there is a saving of copper as well as iron, and it is simply the comparison between the value of the copper and other materials used and the cost of the labour in the two cases which determines, at least in machines of moderate size, whether two or more poles should be adopted.

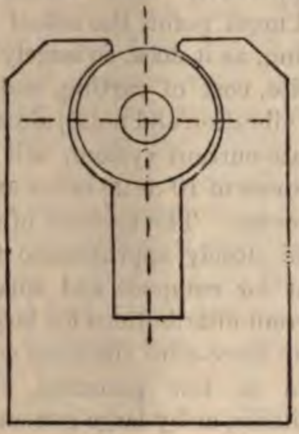

FIG. 3.

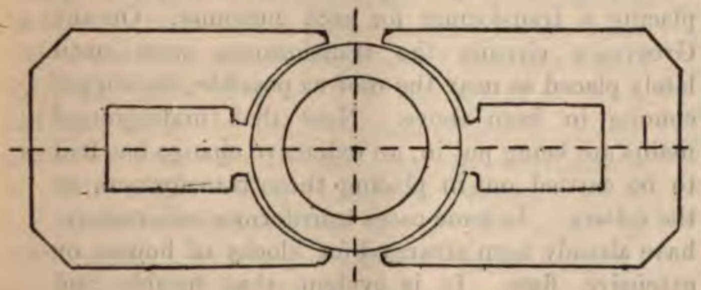

FIG. 4.

In getting out the best relation of L to *d* in the different types of armatures, it is assumed, of course, that the volume being proportional to the diameter, the depth of the winding remains unaltered, as that is the condition which gives uniform rise in temperature. Accordingly, for a given output, the layer of copper on the armature will be of the same depth whether the machine has two poles and an armature having a length of one and a half times its diameter, or four poles and an armature having a length of only half the diameter.

(To be continued.)

MANCHESTER GAS COMMITTEE'S REPORT.

Some time ago the Gas Committee of the Manchester Corporation appointed a sub-committee to make enquiries with reference to the best method of lighting the central portion of the city by electricity. In a report which they have just issued the sub-committee state that they visited Bradford and enquired into the arrangements made there for the supply of electricity under the provisional order granted to the borough by the Board of Trade. The installation is on the continuous-current system, and in the first instance the centre of the town is to be supplied, as in Manchester. The cables are placed under the causeways or pavement. Four feeding mains deliver the current at their outer extremity to four feeding centres situated at different points in the town. About 10 miles of distributing cables connect the various streets and the several feeding centres. The branch line service ends in a terminal box and an electricity meter. The price of the electric current is 5d. per Board of Trade unit, or about double the present price of gas in the borough. The total expenditure has been £35,000, and the revenue for the half-year ended 30th June last was £856. 18s. 6d. The Corporation carried out the work themselves, and obtained the machinery and various appliances from well-known electrical and other engineering firms. Applications for the light have been so numerous that there has not been time to introduce the light into the Town Hall. It is not at present intended to use electricity for public street lighting purposes. The introduction of electricity into the town has not decreased the consumption of gas, as the use of gas for gas engines and for other purposes is being extended, and many persons burn gas during the cold weather for promoting warmth. The sub-committee also give details of the information gleaned during visits paid to the works of the various electric lighting companies in London. The stations visited represented the two systems in operation—viz., the low-pressure "continuous" current and the high-pressure "alternating" current. The best possible example of the low-pressure system is the station of the Pall Mall Electric Lighting Company. The area supplied by this company is limited in extent, being not more than half a mile in radius, and the customers of the company consist of large and wealthy clubs, hotels, theatres, and other establishments using a great number of lights, which is an important economical consideration. The area of supply being small, there is also no necessity in this case for secondary installations or batteries. The other examples of the low-pressure system visited were the Chelsea Electric Supply Company, and the Kensington and Knightsbridge Company. In these cases the area of supply is more extended, and the distances to which the current has to be transmitted is great, so that it is absolutely necessary to place secondary stations and batteries in suitable positions in the district. The other stations inspected were those of the House-to-House Company, the Brush Electrical Engineering Company, the Metropolitan Electrical Supply Company, and the London Electrical Supply Corporation, and these are all on the high-pressure "alternating" current system. The method adopted is to have high-pressure currents on the mains with "transformers," enabling low-pressure currents to be supplied to premises or small areas requiring electricity. These transformers take up little space, and can be conveniently placed in the cellar of premises to be supplied with electricity, or in a cellar to be rented for the purpose, conveniently situated for a small district. Perhaps the most striking example of this system which came under the notice of the sub-committee was the station of the London Electric Supply Corporation, situate at Deptford, from which the high-pressure current is transmitted through the mains to a distance of about eight miles, with transformers at certain points on the route. The low-pressure continuous-current system requires a station to be placed in a position on or near the district to be supplied with secondary stations at convenient points. The high-pressure alternating-current station can be placed at a considerable distance from the immediate district to be supplied, with transformers to low pressure for supplying the premises. Information as to the first cost of supplying and fixing the required plant was readily ascertained, but information as to the actual cost of working could not be obtained. Nor would such information in many cases be useful, inasmuch as most of the installations have but recently been laid down, and are not in full working operation. The committee were not able to gain reliable information as to the exact difference in cost of plant between the low-pressure continuous-current system and the high-pressure alternating current system. It appears that no local authority in the metropolitan district has obtained a provisional order for the supply of electricity, but that the district is divided into a number of areas, which have been allotted to separate private companies. The opinions the sub-committee have obtained and the methods they have seen in operation are so diverse, and the plant so varied, that the committee has not been able to come to a definite conclusion. They suggest that in the initial stages, with a view to obviate mistakes as far as possible, the best professional and disinterested advice should be obtained to draw up a complete scheme, including the most efficient modern and economical appliances for the carrying out of the provisional order. Appended to the report of the sub-committee is a resolution of the Gas Committee giving the sub-committee full power to take such further action in the matter as they may consider necessary and desirable.

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Specimen copies of the paper will be sent on request.

TRANSFORMER SUB-STATIONS.

The invention of the rotary-phase alternate-current motor cannot but give an impetus to what is termed the A.T., or " alternate-current transformer," system against its rival, the B.T., or " battery transformer, " system in new central installations about to be introduced in large towns. Of the two prominent advantages of the direct supply—storage of electrical energy and the capability for driving motors — the latter has now apparently been satisfactorily solved; while a third moot point, the actual cost of generation, depending, as it does, so largely upon questions of rent of site, cost of carting, and liability to injunctions for vibration and noise, already in the favour of the alternate-current system, will become doubly so when distances of 10 or 20 miles are no great difficulty to overcome. The systems of distribution will tend to more closely approximate to two models: direct-current for compact and small districts and alternate-current distributions for large and scattered districts. The three-wire alternate current will then be generated at low potential, either by water power, if available, or by large generating stations at convenient localities; and the current transformed up to 10,000 or 20,000 volts can be transformed down at sub-stations, and used at will either for the supply of rotary-phase motors, or for the distribution of light from suitable sub-stations also on the three-wire system.

The question of the placing of transformers, or of sub-stations, will then become a matter of serious consideration by electrical engineers. The transformer being comparatively uneconomical when not in full use, it is evidently to the interest of the generating company to arrange their transformers, if possible, to serve several houses, a whole block, or a whole street from one single transformer if this can easily be done. At present the usual method is that of placing a transformer for each customer. On the Grosvenor circuits the transformers were until lately placed as near the roof as possible, the supply coming in from above. Now that underground mains are being put in, an extensive change has had to be carried out in placing these transformers in the cellars. In some cases transformer sub-stations have already been arranged for blocks of houses or extensive flats. It is evident that trouble and plant will be saved if this can also be done for streets of houses, which would be supplied on low-tension alternate circuits from one common transformer. The question then arises, where are these transformer stations to be placed? Practically, it is found, we believe, that a single customer is not as a rule willing to allow his cellar to be occupied, for the convenience of the company and his neighbours, by one large transformer, and the fire offices have also something to say on the point, and stipulate fireproof chambers. Where then are the sub-stations to be placed? A cellar may be specially hired and a fireproof chamber built; or, again, a chamber may be constructed under the roadway. In both cases, however, considerable expense is incurred for each sub-station, which would only be warranted when the demand was large and for a considerable district. The position, therefore, seems to indicate that in a growing centre, separate transformers to each house are desirable, at any rate till the demand is fairly general, and then their removal in favour of low-tension mains from a sub-station might be advisable. In America the transformers are more often than not placed in waterproof iron boxes, and are stuck on the outside wall in any convenient position. So far as regards safety from fire, this method would seem almost preferable to leading the high-tension mains into the houses themselves, but the present types of English transformers are not designed for such a practice, which has also an objection on the score of æsthetic effect. The continued multiplication of separate transformers, however, is not desirable, and the settlement of the best way of leading extensions in the direction of a fusion into a system of sub-transformer stations would seem the most important practical question before alternate current electric companies.

ELECTRIC LIGHT AND TELEPHONIC CIRCUITS.

The telephone company that dominates London has upon its board some masters of strategy. During many years' criticism as to overhead wires has been ignored by the company. It has gone on its way rejoicing that its ways were not the ways of the critics. Underground wires—pooh—impossible—too costly—unworkable—don't talk to us, we know our own business best. Just so, that is an undoubted truism. The company knew its own business best. The public paid for a bad service for years, then the end of the tether drew near. A new shuffle brought forward a rearranged board of directors, and the goal in view was to push forward in every direction to the time the last patent lapsed, then cry, Vested interests, touch us not. The last act is to try to obtain powers to put telephone circuits underground. Not till the end has the advisability of this course been accepted. Cynics might say that the attempt is on a par with all other moves. The board wants to show, when the patent expires, that they are anxious to meet the wishes of customers and the criticisms of the public. They will say a large expenditure has been entered upon, and private investments must be held sacred. Good old telephone company! After wasting money in wholesale fashion, it has, through fear, struck you that there is something in favour of underground wires. Discussing the subject with one of the few men who really know every single detail connected with overhead or underground circuits—whose experience is unique, and whose results have been pre-eminently successful—the verdict was absolutely in favour of underground circuits, both for monetary returns and good working. The City Commission of Sewers has referred back to its committee a report recommending that permission be given to the National Telephone Company to lay wires underground, provided the work is done simultaneously with the laying of the electric light cables. This, of course, is in order to prevent the streets being up longer than is absolutely necessary. But the Brush Company suggested that the laying of telephone cables in the same conduits with electric wires required grave consideration. It does; and no doubt sooner or later such laying would have a grave ending. The desire of the telephone company, however, has one advantage—it brings us nearer to the time of "subways" beneath the principal thoroughfares.

THE INSTITUTION BENEVOLENT FUND.

We are very pleased to learn that a Benevolent Fund has been started by the Council of the Institution of Electrical Engineers for future aid to necessitous and deserving members, and we heartily commend this action of the Institution as being admirably fitted to obtain the sympathy and support of the members. Already the members of the Council have generously subscribed to this fund, and we trust ordinary members of the Institution will consider the aims of the scheme and liberally support it according to their means. A similar benevolent fund has been established by the Institution of Civil Engineers since 1864, and from the last report we notice that it has over £37,000 invested, with an annual subscription of £1,468. During last year 45 cases of necessitous members or their families were relieved, the grants representing over £3,000. That our posterity may reap, as Mr. Crompton remarked, the tree must be planted by us. The fund may eventually grow to such a one as that indicated above, and present day electrical engineers may be trusted to respond heartily to the call. The benefits are not intended to be for those simply who subscribe—any member of the Institution whose case needs relief will participate. A general benefit such as this should induce a general support.

MAGNETIC STANDARDS.

Our New York contemporary, the *Electrical Engineer*, is justly jubilant in directing attention to a description in its current number of Eickemeyer's magnetometer. Some time since we suggested the time had come when the trammels of "impossible" should be thrown aside, and practical men should test iron in the lump. We were told that our views were nonsensical, and that it couldn't be done. Subsequently we hinted that Prof. S. Thompson had been requested to test a number of samples of iron, and wondered by what standard he would test them. Our own ideas as to a testing apparatus were rather towards a modification of Jacobi's apparatus, but Mr. Eickemeyer has devised a Wheatstone bridge arrangement, and adopted Norway iron of definite length and cross-section as a standard. This arrangement is described elsewhere, and, among other things, it has been used to get the magnetic value of a mass of iron from a small piece of the original mass. No doubt there is something in the objection that a bulk of iron is not magnetically homogeneous; but we contend now, as we have before, that it is sufficiently so for practical purposes. Our contemporary, in its leader, says: "By casting a test bar with each field magnet, and subjecting it to magnetic tests on the magnetometer, a complete knowledge of each individual piece of magnetic material involved in the construction of machines is obtained." As the apparatus is so simple, we expect to hear that some of the English constructors are about to adopt it. Should they do so, its use will assist to make their productions in the shape of dynamos a little more consistent than they are at present. Might we suggest to some of our more progressive business men that manufacturers might be glad to send samples of iron to be magnetically tested in terms of Eickemeyer's standard, if anyone laid himself out for such testing work.

GUTTAPERCHA CORE.

The issue of the *Electrical Review* for April 3rd contains what is presumably intended as a rejoinder to our criticism of that journal's expression of opinion upon M. Lagarde's experiments on guttapercha core. We can recommend the *Review's* latest contribution to the discussion as a brilliant example of evasiveness. Our contemporary, in one case only, particularises a point at issue. He asks for some proof that most submarine cable specifications drawn up in this country contain a clause stipulating upon a maximum as well as a minimum dielectric resistance. For the information of the *Review*, and in reply to the request made, we may state that Messrs. Clark, Forde, and Taylor stipulate upon a maximum as well as a minimum insulation in their specifications for submarine cables where guttapercha core is used; and in all probability Sir Samuel Canning and other English engineers do likewise. We are glad to comply with our contemporary's request, and are always pleased to render any little service of this nature.

CORRESPONDENCE.

UNDERGROUND CABLES.

SIR,—Noticing the articles of Messrs. Russell and Higgens on "Underground Cables" as they have appeared in your journal, and the references to the draw-in-and-out system, I beg to state we have in this city some experience upon that point.

There has been expended up to this date over six millions of dollars in the construction of subways.

Taking that portion of the city where they were first constructed and longest in use, not 3 per cent. of the streets are occupied.

There are never over four electric light conductors drawn into a 3in. diameter duct. In the smaller diameter ducts there is seldom more than one conductor.

The charge for the use of ducts is from 1,250dols. to 750dols. per mile per annum.

The revenue derived for the rental of ducts does not amount to 1 per cent. per annum on the cost of the ducts.

A large force is continually employed ventilating the subways to prevent explosions.

The atmosphere of the ducts is very detrimental to the insulation of the conductors, which is continually failing. Every electric light company has to have on hand a large supply to replace those that fail.

Not over one-tenth of the streets have subways constructed, and at the rate of those constructed it would take 60,000,000dols. to extend them throughout the built-up portions of the city.

They were commenced in the neighbourhood of Madison-square, the finest portion of the city. It has at least 10 first-class hotels, a number of theatres and palatial residences, and it is a noted fact that it is the darkest portion of the city, when it should be the best illuminated. There are more highway robberies and acts of violence committed in that vicinity than any other.

Who furnished the money to construct these subways is not generally known, but it is supposed the American Bell Telephone did so. They use them to some extent, or, rather, the Metropolitan Telephone Co., which is owned by the American Bell Co

The Western Union Telegraph Company use the overhead railways, under which they suspend lead-covered cables. They reach the roads by stringing cables on the house-tops from their main office. They have to go only two or three blocks to reach the overhead roads.

The draw-in-and-out system until it was tried was very popular. Now it is exceedingly unpopular with both the users and the owners, the latter using every means to get out of their contract for further extensions, the former every means to avoid using them—that is, the subways.—Yours, etc., MANHATTAN.

New York, March 31, 1891.

SHEER THOUGHT.

SIR,—Your correspondent, "A Man of the World," is cynical. No doubt he is also a teetotaller—and we all know the advocacy of extreme measures is an indulgence of such men. I belong to the school of moderation, and believe that water is sometimes bettered by having a flavour, and also that "sheer thought" is the better for a little mathematical concentration. The latter brings about a concreteness that is sadly wanting to those will-o'-the-wisp thinkers whose minds are filled with "ideas" which, after all, turn out to be chimerical ideas. Think, but calculate, should be the aim of every man who desires to make a place in electrical engineering. Your correspondent mentions a lot of names—let me add that of Faraday to the non-mathematicians—but I strongly suspect most of the men mentioned were at any rate, if not Newtons, moderately well acquainted with mathematics, or had someone at their elbows who could calculate for them. It is one thing to be a Faraday; it is another thing to construct machines upon the principles evolved by the genius of experiment. Machines have parts, and each part ought to be designed with a view to its position and work, and this requires calculation. Hence, I suggest the better men to be those who are moderate in combining physical insight with mathematical ability.—Yours, etc., No. 2.

PRACTICAL OR MATHEMATICAL.

SIR,—What is concrete imagination anyhow? And what is the difference between concrete and abstract imagination? Further, what relation does either bear to sheer thought? Mr. Ferranti is, no doubt, a brilliant exception to the ordinary rule, but I should fancy that in nine cases out of 10 he finds the more prosaic but safer course to lie in "putting down" a few figures when designing. The Patent Office records are full of a great many examples of abstract imagination—or shall I say abstracted imagination?—which have never been figured out, and, therefore, never assumed concrete form.

I once designed a henhouse in the days of my youth by the sheer thought process; the result led me to avoid that method ever after. I now temper my abstract imagination, or, as you put it, "translate" my ideas "downwards to signs."—Yours, etc. PRACTICE-WITH-THEORY,

JOEL'S SLOW-SPEED DYNAMO.

Our illustration shows a new type of the dynamo manufactured by Messrs. Henry F. Joel and Co., of 31, Wilson-street, Finsbury, which is found to have special advantages.

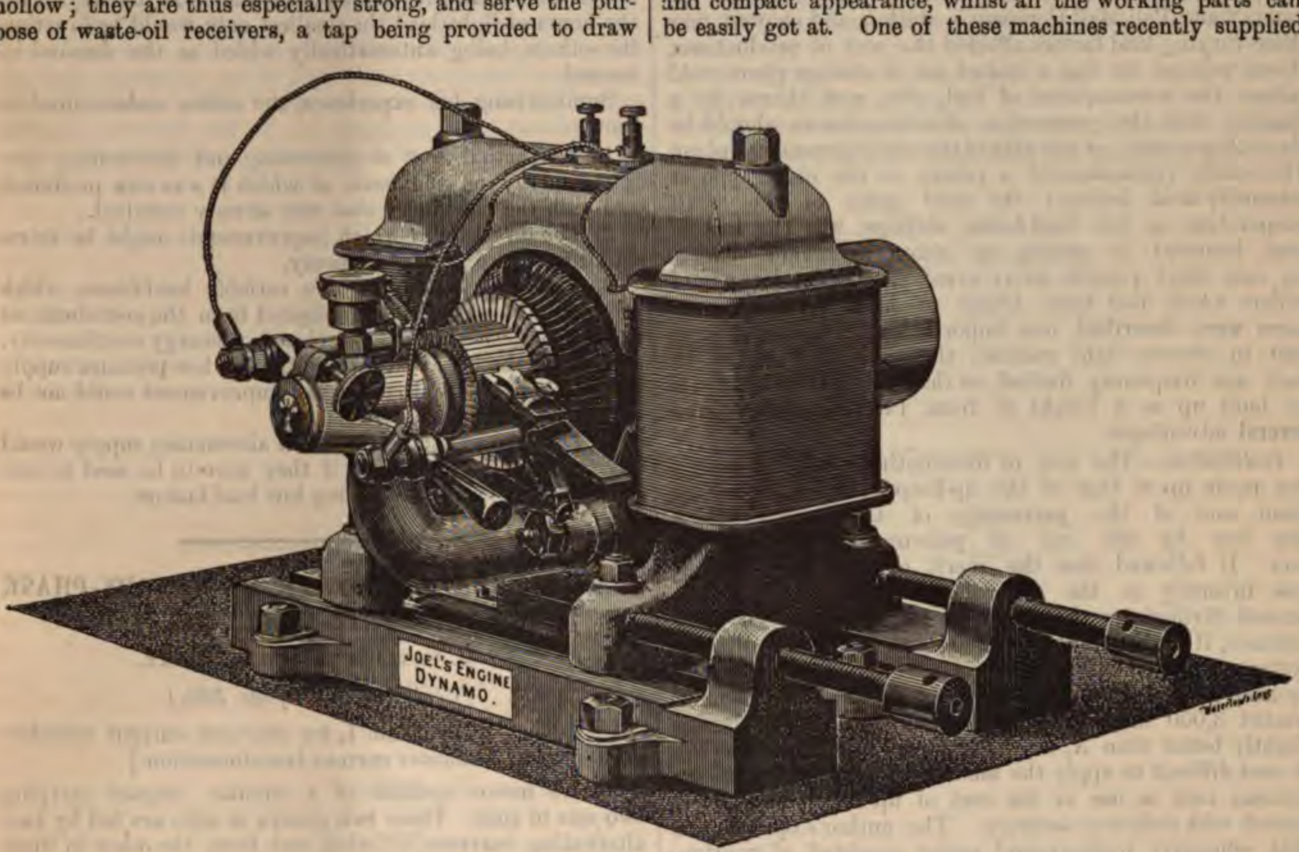
JOEL'S ENGINE DYNAMO.

FIG. 1.

The bearing arms carrying the axle are horn-shaped and hollow; they are thus especially strong, and serve the purpose of waste-oil receivers, a tap being provided to draw off the waste oil; at the same time the rounded surfaces do not permit any accumulation of dust. The bearings are very long, and are arranged with oil channels at each end. The poles are of cast iron shaped to obtain the greatest magnetic efficiency, and are also of a rounded form; the field cores are of the very best hammered scrap wrought iron, annealed.

The commutator is very large, and one of the best features of the machine is that the brushholder can be easily and quickly taken off for clearing and adjustment. The brushes are fitted with pointers to show their position, and with adjustable spiral springs for contact pressure, as well as stops to keep them off the commutators.

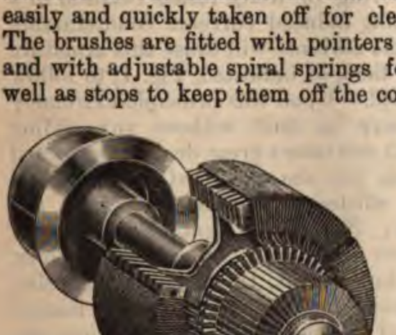

FIG. 2.

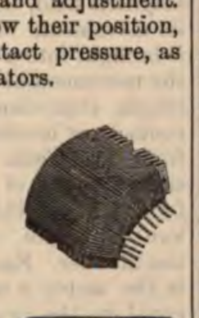

FIG. 3.

Figs. 2 and 3 also show the complete armature, which is built up of sections or groups of laminated iron plates, of segmental shape. These sections interlock, fit into each other, and are fastened by bolts to spokes, and thus form the rim of the wheel. The insulated wire coils are separately wound, and are threaded on the core sections. The ends of the coils are connected in a special and convenient manner to the commutator, and can be quickly disconnected.

The mechanical details are worked out to secure great simplicity, and to enable the dynamo to be easily and quickly taken to pieces, and put together again without special skilled labour. This is useful on board ship, in the country, and other places where an easily-repaired machine is necessary.

The whole, with its rails, is an example of the best type of mechanical construction, combined with electrical and magnetic adaptability, and the machine has a very handsome and compact appearance, whilst all the working parts can be easily got at. One of these machines recently supplied to Messrs. Crossley gives 40 16-c.p. lamps with a 3-h.p. gas engine, and an efficiency of nearly 90 per cent.

THE COST OF THE GENERATION AND DISTRIBUTION OF ELECTRICAL ENERGY.*

BY R. E. B. CROMPTON, M.I.C.E.

Machinery for the supply and distribution of electrical energy came under two heads—namely, the generating plant, comprising boilers, steam dynamos and switching apparatus, and the distributing plant, consisting of a network of conductors, supplemented in some cases by accumulators, and in other cases by transforming apparatus to change energy from high pressure to low pressure.

Part 1.—Cost of Generation.—With the high efficiency of 96 per cent. which was now attainable in dynamos, the cost of the electrical energy ought only to be a small fraction in excess of that of a corresponding amount of mechanical energy. The wide difference between the calculated amount and the figures attained in practice were considered. The three items of cost—namely, material, labour, and upkeep—were influenced chiefly by the "load-factor," the design and arrangement of the plant, and the local cost of material and labour.

The author had given the name of load-factor to the relation which the actual output of any given plant bore to what would be its output if it were worked continuously at the full load. In order to compare the relative economy of fuel, water, or other material used in generating electrical energy, he had fixed on a consumption of 25lb. of water and 2½lb. of Welsh coal per unit generated as a standard which might be reached in the future, although nothing approaching those figures had yet been attained in practice.

He then proceeded to describe the electrical supply stations from which the data for the paper had been obtained—namely, the Kensington and Knightsbridge Electric Lighting Company, and the St. James's and Pall Mall Electric Lighting Company. The load-factor of these stations varied from the exceedingly low figure of 2·5 for the Kensington station in the month of August to 41·5 on one occasion, which was the best load-factor of the St. James's and Pall Mall Company's station, and showed how these varying load-factors affected the cost of productions. It was pointed out that a limited use of storage plant could reduce the consumption of fuel, etc., and shown by a diagram that the proportion of accumulators should be about 20 per cent., or one-fifth of the whole generating plant. The author recommended a return to the older type of internally-fired boilers; the chief cause of the small evaporation, in low load-factor stations, was the loss of heat incurred in getting up steam in several boilers for only short periods every evening. Several types of boilers which had been found to have special advantages were described, one important consideration being that in electric light stations the space from front to back was frequently limited, so that a boiler which could be built up to a height of from 14ft. to 16ft. offered several advantages.

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* Abstract of paper read before the Institution of Civil Engineers.

Distribution.—The cost of distributing electrical energy was made up of that of the up-keep of the distributing plant and of the percentage of the energy which was lost by the fall of pressure in the conductors. It followed that the merit of competing systems was inversely as the cost of generating the units so wasted divided by the up-keep of the conductors. For instance, if in distributing 20,000 units to a given distance system A wasted 1,000 units in a given time, the cost of up-keep for the same time being £10, whereas system B wasted 3,000 units at a cost of up-keep of £3, B was slightly better than A, because $\frac{3000}{10} : \frac{1000}{3}$: : 300 to 333. It was difficult to apply the method of comparison to the systems now in use as the cost of up-keep was not yet known with sufficient accuracy. The author's opinion was that whenever underground mains consisted of continuously-insulated cables the sum required for up-keep would be not less than 4 per cent. of the original cost, and was not likely to exceed 7 per cent. When, however, the underground mains took the form of bare copper conductors with glass or porcelain insulators the cost of up-keep might be as low as from 1 to 2 per cent. In this connection the distribution system of the Kensington and Knightsbridge Company was described, and reference was made to the systems of supply for St. James's and Pall Mall, Westminster, Notting Hill, and for the St. Pancras Vestry, also that in use at Birmingham.

The author had found difficulty in obtaining accurate accounts of the cost of distribution by the alternating-transformer system, but all the published accounts had shown that the total net cost per unit was greatly in excess of that of the low-pressure system. The author had under his charge a plant of generating and distributing machinery on the alternating-transformer system for the public lighting of Chelmsford, a small private demand existing in addition. In this case the machinery was worked for long periods at a high load-factor, so that the cost of generating was exceptionally low, and as the load in the transformers was perfectly regular it had been possible to so proportion them as to be worked continuously at their maximum efficiency. A table showed the load-factors for this station for the month of August and December, 1890, and a 24 hours' load diagram, taken on the 20th January, 1891, was exhibited. The annual load-factor was found to be 31·0, and the pounds of coal per unit generated, 8·88; the pounds of coal per unit delivered, 10·70; hence the efficiency reached 83 per cent. But this was an extremely favourable example, and an alternating-transformer installation in a medium-sized private house in the Kensington district, tested by Prof. Ayrton, was found to have a mean annual efficiency of only 53 per cent. The remedy for this defect in the alternating system consisted in what had been called "banking," the transformers. This meant that a district to be supplied with electricity should be laid with a low-pressure network, in all respects similar to that provided for the direct low-pressure system; but in place of the feeders, and at the point where the feeder mains were connected to the network, a fireproof and incombustible chamber should be formed under the surface of the roadway. In this a number of transformers of graduated sizes were arranged, with the high-pressure mains connected to them, so that the transformers might be switched into action automatically as required, that was to say, during the hours of light load the smallest only would be in action, the others being automatically added as the demand increased.

Summarising his experience, the author endeavoured to show:

1. The actual cost of generating and distributing electrical energy on the scale at which it was now produced, and with the machinery that was already installed.
2. The direction in which improvements might be introduced to secure greater economy.
3. The important effect of a variable load-factor, which might be almost entirely eliminated from the cost-sheets of those who desired to employ electrical energy continuously.
4. That the losses on distribution in low-pressure supply were already so low that further improvement could not be expected.
5. That the existing systems of alternating supply would have to be greatly modified if they were to be used in residential neighbourhoods having low load-factors.

TRANSMISSION OF POWER BY ROTARY-PHASE ALTERNATE CURRENTS.*

BY M. VON DOLIVO-DOBROWOLSKY.

(Continued from page 336.)

[*Erratum.*—p. 336, line 1, for *alternate* current transformation, read *continuous* current transformation.]

Tesla's motor consists of a circular magnet carrying two sets of coils. These two groups of coils are fed by two alternating currents, differing one from the other in their phase by 90deg.; so that, for instance, in the coils II there is no current, when in the coils I. the current is at its maximum, and while the current in II. is rising from 0 to its maximum, the current in I. is sinking from maximum to 0, etc. As shown diagrammatically in Fig. 1, a rotary magnetic field (the so-called Ferraris or rotary field) arises in the interior of the magnet system. The interior enclosed space therefore behaves nearly as if the magnetic field were constant and mechanically revolving. Now, an armature, the windings of which are short circuited (or, a massive ring of iron), resists rotation in a magnetic field, there being induced currents counteracting its movement. The same currents will cause this armature if brought into a rotary field, as indicated, Fig. 1, to follow the movement of this field. Upon this principle extremely simple electromotors may be built without any sliding contacts or brushes. At one time a great deal was expected from the Tesla motors, yet the fact that these motors cannot prove of high efficiency may be seen from the following consideration: Fig. 2 represents a diagram of two alternate currents displaced by 90deg. against one another. Each of the currents, I. and II., is exercising in the motor a magnetising force, which is at each instant equal to the product of the number of windings into the instantaneous current strength. The total magnetising force exciting the motor magnets is equal to the sum of both ampere-turns, and is, therefore, a function of the sum of the two currents. In practice, however, this sum is by no means a constant quantity. It is true that in Ferraris's arrangement the resulting force of the two perpendicular coils upon an ideal magnet pole is indeed to be assumed as constant, yet this does not hold good with regard to actual motors and machines, where the usual rules of electromagnets are applicable. In considering Fig. 2 we see that the absolute value of the sum of the currents, I. and II., is fluctuating between the limits i and $2\ i \sin 45\text{deg.}$, if we denote by i the maximum of each current; for at the moment when one current is at its maximum $= i$, the other one is $= 0$, hence their sum $= i$. Further, when the two currents are mutually equal as at the time *t*, each current is = *i* sin 45deg., consequently their sum = 1·4 *i*. Thus the total number of ampere-turns exciting the motor is fluctuating by 40 per cent. of its maximum value, and consequently the field of Tesla's motor is not only rotating, but also strongly pulsating. The actual mode of operation of this motor is, therefore, far less simple than was at first assumed. We may, however, consider these two actions, the rotation and the pulsation of the field, separately, as in the alternate-current motor of Elihu Thomson. This motor consists of a field fed by an alternate current and of an armature short-circuited in itself; like all synchronous alternate-current motors, it must be first brought by some special arrangement to the right speed before the alternate current takes up the work. At overloads it suddenly stops, the pulsations of the field being able to impart motion only at a certain speed; and, on the contrary, at any smaller speed having a hindering and jerking action, as the currents induced by the pulsations in the short-circuited armature do not appear at the right time and position as regards the field. For this reason a stationary short-circuited armature starts with difficulty in an alternate-current field. Now, a Tesla motor—or, generally, a two-phase motor—has, as we have seen above, a magnetic field pulsating by 40 per cent. in its intensity; it must, therefore, partly possess the properties of the Thomson motor; as long as Tesla's short-circuited armature is not running synchronously with the field, its driving power is only equal to the difference between the impulse of its rotary field and the jerking action of the pulsating magnetism. Hence, the Tesla motor starts with difficulty at a load, and has at its full speed the tendency of remaining synchronous up to a certain limit of load, beyond which its speed and driving power rapidly decrease. The practical use of this motor is therefore relatively limited, and it represents only an improvement of the completely synchronous Thomson motor, inasmuch as it is possible to start of itself at a moderate load on turning on the current. A good motor, free from the fault due to synchronism, can be obtained on the principle of the rotary current, only by diminishing the intensity of the pulsations in the magnetic field. An ideal rotary field would be one that was absolutely constant; its lines of force only ought to be rotating, just as if it were a revolving electromagnet fed by a continuous current. This ideal is approached by increasing the number of currents mutually displaced in their phases; it is, however, by no means necessary to take a great many currents. A glance at Fig. 3 shows us that already with three currents the sum of these currents becomes sufficiently constant. In fact, the sum of absolute values of the three currents at the time *t* is

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* Translated from the *Electrotechnische Zeitschrift.*

$$2 \sin 60\text{deg.} \times i \max = 1{\cdot}732\, i \max,$$

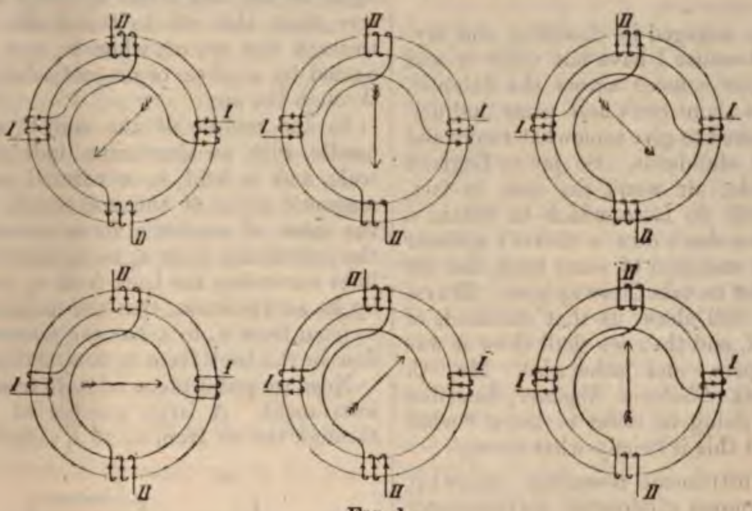

FIG. 1.

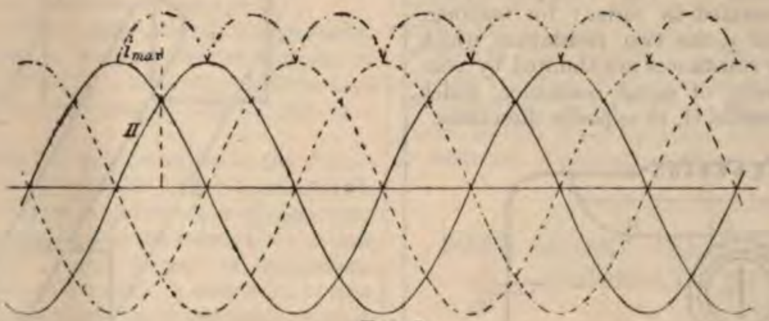

FIG. 2.

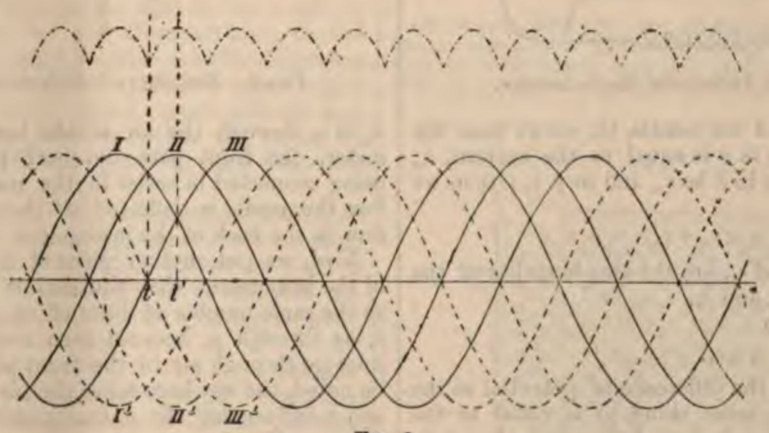

FIG. 3.

and at the time t^1

$$2 \sin 30\text{deg.} \times i \max + i \max;$$

i.e., $= 2\, i$ max. The field pulsation corresponding to this fluctuation is thus with three currents 15 per cent. only, against 48 per cent. in Tesla's motor. If the number of alternations is relatively small, the saturation of iron may be assumed higher without any disadvantage to the efficiency and with only 15 per cent. fluctuation of ampere-turns, the total quantity of magnetism will practically remain constant.

(To be continued.)

EICKEMEYER'S DIFFERENTIAL MAGNETOMETER.

While we in England are engaged in doubting, and saying that "it can't be done because I have not done it and it is not in text-books;" our cousins across the Atlantic, with that total lack of cant about can't and utter indifference to authority, are prepared to give somewhat rough and ready, but useful, magnetic standards. So far as England is concerned, iron won't do, air won't do, and, in fact, authority says nothing will do from which to obtain a standard. America says, we don't care a tinker's whisper what you say; we want a standard of some kind, and till someone provides a better let us take Norway iron. Bravo, America. No doubt you will show us that standards of practical utility can be had, and then we shall show it was all foretold here in papers, and otherwise. Mr. C. Steinmetz, in the New York *Electrical Engineer*, describes what Eickemeyer has been doing in order to know "what kind of iron you have," and this is briefly what he says:

The principle of this instrument resembles somewhat the principle of the well-known differential galvanometer applied to the magnetic circuit. In Fig. 1, suppose F_1 and F_2 were two E.M.F.'s connected in series; for instance, two cells of a battery, x and y, the two resistances which are to be compared. Both resistances are shunted by conductors, a and b respectively, of equal resistance, which influence a galvanometer needle, G, in opposite directions.

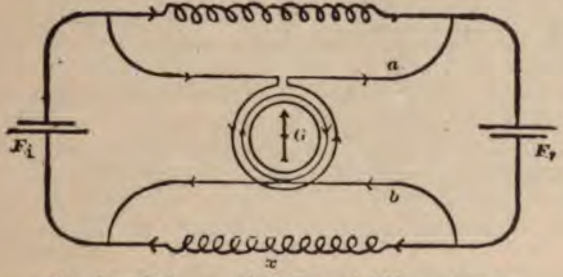

FIG. 1.—Eickemeyer's Differential Magnetometer.

Then the zero position of the needle, G, shows that the electric current, c_a, flowing in a is equal to the current, c_b, in b. But, let the current in x be c_x, and in y c_y; then we must have

$$c_a + c_y = c_b + c_x;$$

because the currents, c_a and c_y, are the two branches of the same integral current as c_b and c_x.

Therefore, if $c_a = c_b$, then

$$c_x = c_y.$$

But, if $c_a = c_b$, and $a = b$, the difference of potential at the ends of a (or, what is the same thing, y) is equal to the difference of potential at the ends of b or x, and, therefore, the current in x and y and the potential differences being the same, it follows that $x = y$.

That is, this method of connection allows us to compare an unknown resistance, x, with a standard resistance, y.

Now, instead of "electric current," say "magnetic current" or "number of lines of magnetic force"; instead of "electro-motive force" or "potential difference," say "magneto-motive force"; and instead of "electric resistance" say "magnetic resistance," and we have the principle of Eickemeyer's magnetic bridge, or differential magnetometer.

Indeed, for electric measurements, only one E.M.F., F, would be sufficient. But the air, as well as the material to be measured, being a magnetic conductor, the use of two equal magneto motive forces in series at two 'diametrical points of the magnetic circuit is necessary to keep the opposite points of the circuit at the same magnetic potential.

The magnetic circuit of the Eickemeyer differential magnetometer consists of two pieces of best Norway iron, ⊔⊓-shaped, shown in the diagram, Fig. 2, at F_1 and F_2. The middle portion is surrounded by a magnetising coil, C. If the coil, C, is traversed by an electric current, the front part, s_1, of the left iron piece becomes south, and the back part, n_1, north polarity; the front part of the right iron piece, n_2, becomes north, and the back part south; and the lines of magnetic force travel in the front from the right to the left, from n_2 to s_1; in the back the opposite way, from the left to the right, or from n_1 to s_2, either through the air, or, when n_2 and s_1, or n_1 and s_2 are connected by a piece of magnetisable metal, through this and through the air.

In the middle of the coil, C, stands a small soft iron needle with an aluminium indicator, which plays over a scale, and is held in a vertical position by the lines of magnetic force of the coil itself, deflected to the left by the lines of magnetic force traversing the front part of the instrument from n_2 to s_1, deflected to the right by the lines traversing the back from n_1 to s_2. This needle shows, by its zero position, that the magnetic flow through the air in front from n_2 to s_1 has the same strength as the magnetic flow in the back from n_1 to s_2 through the air.

Now we put a piece of soft iron, x, on the front of the instrument. A large number of lines go through x, less through the air from n_2 to s_1; but all these lines go from n_1 to s_2 through the air at the back part of the magnetometer, the front part and back part of the instrument being connected in series in the magnetic circuit. Therefore the needle is deflected to the right by the magnetic flow in the back of the instrument.

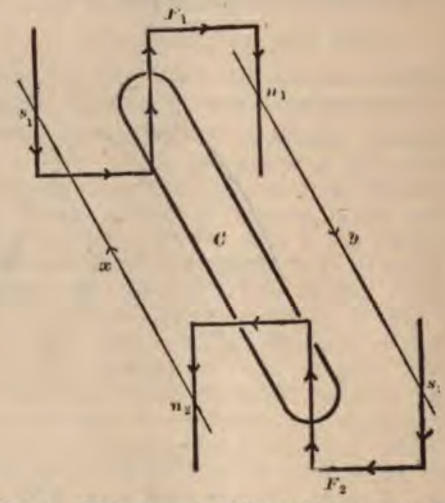

FIG. 2.—Eickemeyer's Differential Magnetometer.

Now, we put another piece of iron, y, on the back part of the instrument, then equilibrium will be restored as soon as the same number of lines of magnetic force go through x, as through y, because then also the same number of lines go through air in the front as in the back. As will be noted, the air here takes the place of the resistances, a and b, influencing the galvanometer needle, G, as in the diagram, Fig. 1.

The operation of the instrument is exceedingly simple, and is as follows: Into the coil, C, an electric current is sent, measured by an ammeter, and regulated by a resistance. Then the needle which before had no fixed position points to zero.

Now, we lay the piece of iron, the magnetic properties of which we want to determine, on the back part of the instrument. The needle is deflected to the left. On the front of the instrument we put Norway iron rods of known cross-section and known magnetic conductivity, until equilibrium is again restored. Then the iron in the front has the same magnetic resistance as the iron in the back, and the ratio of the cross-sections gives directly the ratio of the conductivities; so that by a single reading the magnetic conductivity of any piece of iron can be compared with that of the Norway iron standard.

For absolute determinations, the iron is turned off into pieces of exactly four square centimetres cross-section, and 20 centimetres in length, both ends fitting into holes in large blocks of Norway iron, which are laid against the pole-pieces of the magnetometer, so that the transient resistance from pole face to iron is eliminated.

An example may show the operation more clearly: A piece of very good annealed cast steel is laid into the blocks in the front of the magnetometer. It has the usual size of 20 centimetres length and four square centimetres cross-section. An equal rod of best Norway iron, the standard, is put on the back of the instrument. The needle is deflected from zero, but not much; the cast steel is very good. To bring the needle back to zero, we have to add in the front ·2 square centimetre of Norway iron.

Therefore, four square centimetres of Norway iron have the same magnetic conductivity as four square centimetres of this cast steel + ·2 square centimetres Norway iron; or, four square centimetres of cast steel = 3·8 square centimetres Norway iron; that is, the magnetic conductivity of this kind of cast steel is as high as 95 per cent. of that of Norway iron!

We now change the magnetising current in C, decreasing it from 7·5 to ·5 ampere. We now have to add ·5 square centimetre of Norway iron to restore equilibrium. Therefore, for very low magnetisation the magnetic conductivity of this cast steel is only $= \frac{35}{40} = 87{\cdot}5$ per cent. of Norway iron. For high magnetisation it increases up to 96 per cent.

To get rid of the residual magnetism, a reversing switch allows us to reverse and to break the current in C.

Such a determination is done very quickly, and permits, in half an hour, the testing a large number of samples of iron, delivered from foundries, etc., to choose the iron best suited for the intended use, and not to buy a "pig in a poke."

To determine the intensity of magnetisation in the iron—that is, the number of lines of magnetic force—a coil, which we may call B, of a known number of turns, is slipped over the standard magnetic resistance, and the current in C—that is, the magnetism—reversed. The reversal of magnetism induces an E.M.F. in the coil, which is measured by the throw of a galvanometer needle, and gives the exact number of lines of magnetic force in the standard.

This magnetometer is used in Mr. Eickemeyer's factory with the greatest success for the determination of the field-magnet iron in the dynamo machinery in the following way: On the very iron frame of the dynamo or motor which constitutes its magnetic field, is cast a square piece of iron 8in. long and 1¼in. square. This is broken off, turned off in the middle for a length of 4in. and to 1⅛in. diameter, and placed on one side.

This piece of iron is compared in the magnetometer with the Norway iron standard, and thus gives for each machine the magnetic properties, not only in general, of the kind of iron used, but of the very casting which constitutes the dynamo field. By means of this the field winding is determined; more can hardly be expected.

Mr. Steinmetz says that by testing a very large number of different sorts of cast iron and steel, many interesting results are found; for instance, that for cast iron with very low magnetisation the conductivity is often as low as 30 to 40 per cent. of Norway iron, but increases with increasing magnetisation up to 80 per cent. and more. Some kinds of annealed steel are even better than ordinary wrought iron; one sample attained for average magnetisation (7·5 amperes) 97½ per cent. of Norway iron.

The indicator needle, in the middle of the coil C, is closely surrounded by a small coil. This, when excited in the opposite direction to the main coil, C, decreases its directing force and thereby increases the sensitiveness of the instrument, which is very useful for high magnetisation where the directing force of C is very great. This "astatic coil," when kept excited in the same direction as the main coil, C, after the current in C is broken, affords the means for determining remanent and permanent magnetism by the coil B. This coil B is slipped over the standard resistance at the other side of the bridge, being the sample of iron to be tested for its hysteresis. Then, after breaking the main current in C the needle is directed only by the small coil, which has no influence upon the magnetic circuit of the magnetometer, and therefore the needle is deflected by the remanent magnetism. Now the needle is brought back to zero by a current in coil B, and this current, measured by an ammeter and regulated by the resistance switch, gives the magnetomotive force of remanent, or, when a permanent magnet is used, of permanent magnetism. Pieces of Norway iron of known cross-section are used as fractional standard resistances.

One Norway iron standard, exactly like the normal standard, is cut into two pieces, well fitted to each other, which, when withdrawn, leave a gap between them, for testing sheets of different materials or even liquids brought into the gap or air spaces.

For instance, if an air gap of $\frac{1}{32}$in. is left between the two pieces of Norway iron, then the magnetic conductivity for very low magnetisation is decreased by this air gap to only about 20 per cent. of the unbroken standard, but increases for increasing magnetisation, until, for very high magnetisation, this air gap has almost no influence upon the magnetic circuit. This, from the known saturation curve of the Norway iron standard, allows of determining the magnetisation (the number of lines of magnetic force) by means of the behaviour of air gaps, without always going back to the use of the ballistic galvanometer. And thus a large number of applications of this instrument for magnetic tests have been made. Still more can be devised which cannot be further referred to here, its usefulness having been sufficiently shown.

The lower part of the desk upon which the instrument is mounted contains accommodation for a storage battery for giving the exciting current. Terminals allow a current to be sent in from outside, as is often more convenient in an electric factory. Switches and cut-outs regulate and control the different circuits, and the back part contains the resistances, so that the instrument, with the desk upon which it is mounted, is entirely self-contained.

SOME RECENT IMPROVEMENTS IN LEAD SECONDARY BATTERIES.*

BY J. T. NIBLETT, MEMBER.

(Continued from page 339.)

Carpenter's Elements.—Mr. H. Carpenter, of New York, makes battery elements of hollow perforated lead boxes, packed well in with cerussite (native carbonate of lead), which is reduced to an oxide in one case and spongy lead in the other by electrolysis.

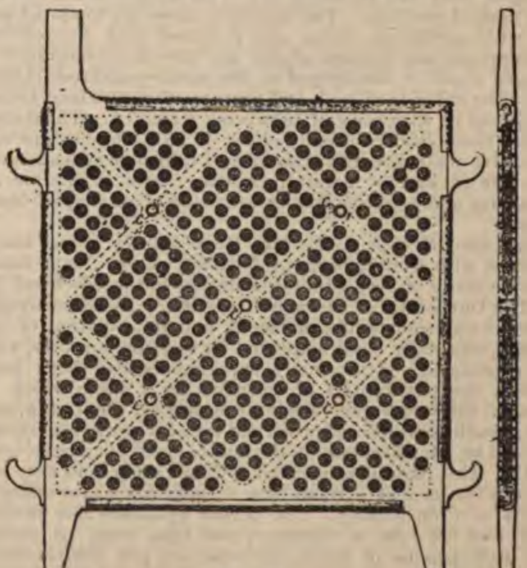

Fig. 14.

Knowles' Elements.—These elements, Fig. 14, consist of solid blocks of active material, firmly clamped between two perforated plates made of an inoxidisable alloy. These conducting plates are held together by rivets, which pass through the active material. The perforations allow the electrolyte a fairly free access to the oxides and spongy lead. As the slabs of active material are free to expand or contract in any direction throughout their mass, these elements are said never to warp or buckle, even when seriously overcharged, or over-discharged.

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* Paper read before the Physical Society of the Glasgow University, 13th January, 1891.

Hagen's Improved Lead Frames.—Mr. Hagen, of Kalk, near Cologne, has recently devised a form of metal frame for holding the active material, which is said to be of less dead weight, but equally as strong, as the grids usually employed in this country. The frames may be made of any of the alloys now used for holding the active material. Each frame consists of two halves formed of ribs crossing each other at right angles, and leaving square apertures. Each rib is in the form of a triangular prism with its base outwards. The halves are not cast solid along the inner angle of the ribs, but are some little distance apart, and are merely held together where the ribs cross by a series of short cross-bars, the whole frame being cast in one piece. In this way a light but strong frame is obtained, which is not only capable of holding a large amount of active material, but holds it permanently, as it is prevented from falling out owing to the ribs being of a triangular section.

Laurent-Cèly Accumulator.—The chief features in this form of battery are the peculiar nature of the active material used, and the manner in which this material is applied. The active material is a mixture of chloride of lead and chloride of zinc. The fused chloride of lead employed has an initial density of 5·6; but by incorporating chloride of zinc with it in certain proportions, the density is reduced to 4·5. This mixture is melted, and is run into cast-iron moulds made in the form of small buttons with rounded edges. After cooling, the buttons are washed to remove the chloride of zinc, and are thus rendered somewhat porous. Their density then varies from 4·2 to 3·4. The buttons which serve for the manufacture of the negative plates are arranged in a metallic mould, into which an alloy of lead and antimony is run; this frame holds the buttons in the desired position. The negative plates are mounted in cells filled with acidulated water, and provided with zinc electrodes. The composite and the zinc plates are then short-circuited. The hydrogen which is disengaged at the positive electrode chemically reduces the chloride of lead, and there are thus obtained buttons of spongy lead of a density of between 2·5 and 3·1. The density of ordinary sheet lead is usually about 11·35. The buttons used in the positive plates are first transformed into spongy lead, and then into oxide of lead by carefully heating them in the air. Both the positive and negative frames are made of an alloy of lead and antimony.

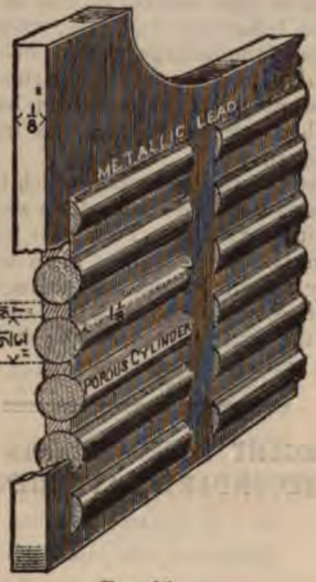

FIG. 15.

Reckenzaun Storage Cell.—Mr. Reckenzaun's name has been associated with storage batteries for many years. Some time back he gave a series of very admirable articles in the *Electrical Review* on "The Durability of Storage Batteries." In these articles the important question of the efficiency and depreciation of storage batteries, especially when employed for traction purposes, was very fully considered. After many experiments had been made to ascertain the possibilities of constructing a plate which would withstand the very rapid variations of output, the jolting, and the rough handling which cells used for tramcar work are sure to be subjected to, Mr. Reckenzaun devised his porous cylinder element, Fig. 15. This plate it is asserted will not warp, and may even be bent into the form of a small tube without the active material falling out or even scaling. The porous cylinders are shaped in a mould, and are $\frac{7}{16}$in. in diameter, and $1\frac{1}{8}$in. long. A number of these little pencils of active material are put into cavities in a metal chill $\frac{1}{2}$in. distant from centre to centre, and the molten lead is poured in. As a result, a plate is produced whose metallic part is about $\frac{1}{8}$in. thick, so that a portion of the porous cylinders protrude on either side, and thus expose a large active surface to the electrolyte. During the electrolytic action each little porous rod expands, chiefly along its own axis, which lies parallel to the surface of the plate, and therefore tends to elongate, but not to bend or buckle it. The increase in the diameter of the cylinders serves to make more effective contact with the metal support. As the metal employed is pure lead, and therefore very soft, it offers but little resistance to elongating influences.

Another novel method of producing storage battery elements is due to Mr. Reckenzaun. He found that lead, when placed within an electric arc, was quickly converted into an oxide. Working on this idea, he caused an electric arc to travel over the surface of a plain lead accumulator plate, and he found that he could by this means transform the entire surface to any desired depth into peroxide of lead. The oxides formed in this manner do not show any disposition to scale or fall off when placed in an acid solution, or when being subjected to electrolytic action.

In a lead storage cell the water is slowly split up into its constituents—viz., oxygen and hydrogen; the nascent oxygen liberated attacks the metal forming the positive element, and slowly oxidises it; the hydrogen is either occluded by the spongy metal of the negative plate, or it escapes into the air. By Mr. Reckenzaun's method he utilises the intense heat of the electric arc to induce rapid combination between the oxygen of the atmosphere with the lead, and produces in a few minutes the same amount of chemical combination that would take days or even weeks to produce by the slow process of decomposing water by the electric current.

The Brush Secondary Battery.—This battery, Fig. 16, which is an American production, was devised by Mr. C. F. Brush, of Cleveland. Both elements are cast in lead, and have a number of narrow grooves on either side. After being chemically cleaned, the castings are immersed in a solution of acetate or nitrate of lead, or any other solution capable of depositing spongy lead when electrolysed. The plates under treatment are made the cathode in the depositing bath, while a stout piece of sheet lead constitutes the anode, or loss plate. After being subjected to electrolytic action until the requisite quantity of spongy lead has been deposited, the plates are taken out and thoroughly washed. When placed in the ordinary dilute sulphuric acid solution, the spongy lead on the positive element is quickly converted into peroxide by the current.

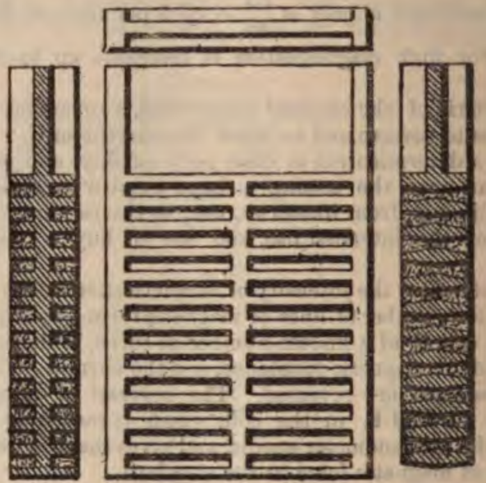

FIG. 16.

Another method of rendering these plates active consists in filling in the grooves with sulphate of lead made into a paste with water or some saline solution. When dry and hard, the plates are placed horizontally in a vessel containing a solution of common salt, or ammonia, or any other salt in which sulphate of lead is somewhat soluble. A zinc plate is suspended in the solution, above each lead plate, and a metal wire joins the two. A galvanic couple is thus produced, which sets up electrolytic action, and gradually reduces the sulphate of lead into the spongy metal. After being well washed, either in pure or acidulated water, the plates are placed in the containing cells, dilute sulphuric acid is added, and by means of the current the spongy lead on the positive elements is quickly transformed into peroxide.

Bailey's Series Battery.—This battery, as designed by Mr. Mark Bailey, consists of a rectangular wooden box divided into separate cells by the battery plates. The plates are cast with square recesses for holding the active material. The opposite sides of each plate are of different polarities. The metal partitions constituting the cells are therefore in series, and no electrical connections whatever are required except at the two end plates. A light wooden frame, which has been treated with paraffin, is inserted between each plate to prevent buckling. A box 14in. long, $4\frac{1}{2}$in. wide, and 6in. deep will contain 24 plates—that is, 24 cells; and a battery of these dimensions, it is asserted, will maintain a discharge of 18 amperes at a potential of 48 volts. The great point in this form of battery is to prevent leakage of the solution from cell to cell. To this end the lead plates are let into grooves made in the sides of the wood containing-case, and a fillet of acid-proof cement is run in the interstices, which serves to make each compartment liquid-tight.

Another modification of this form of cell consists of a number of circular grooved discs, filled in with active material, and built one upon the other. A specially moulded indiarubber ring and flange, about $\frac{1}{4}$in. thick, keep the elements a sufficient distance apart to allow room for the electrolyte. A hole in the centre of each plate permits a small vent tube to go down into each cell, thus forming an outlet for the gases when generated.

Ernst's Intercirculatory Storage Battery.—Quite recently an interesting form of element has been introduced in America by Mr. Victor Ernst. It is termed an "intercirculatory" battery, owing to the electrolyte being free to permeate through and act upon every particle of the active material. The fundamental principle involved in the new element is an absorbent core having an expansive action. This flexible core is made of asbestos fibre, wool, hair, or other similar substance. It ramifies through the interior of the active material in such a manner that the oxide or spongy lead is retained in close contact with the walls of the metallic holder or plate, giving perfect electrical contact and conductivity. The elastic core presents a yielding surface to the active material, so that any jolting or concussion occurring when the batteries are used for transition purposes does not tend to break up or dislodge the soft lead or oxide. An absorbent action is also obtained through the medium of the porous core, which causes the electrolyte to diffuse uniformly throughout the elements, thereby enabling the batteries to receive or maintain a high rate of charge or discharge without the internal resistance of the cell largely increasing.

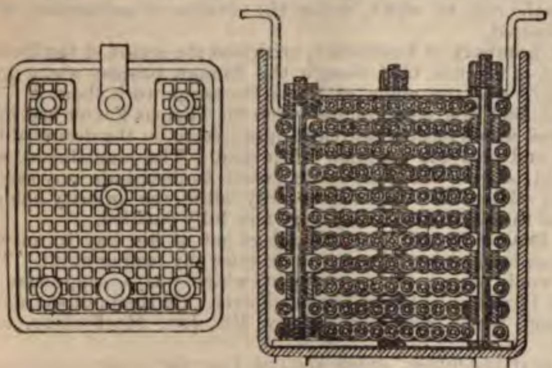

FIG. 17.

The increase in the internal resistance of cells is frequently due to surface exhaustion, caused by a too rapid rate of discharge. The battery elements, Fig. 17, are built up horizontally, being placed one above the other. No lead-burning or soldering of any kind enters into the construction of these plates, as the elements are held together at the requisite distances apart by means of indiarubber washers and vulcanite nuts and bolts.

The Atlas Accumulator.—The "Atlas" storage battery, Fig. 18, is the name given to a new form of cell, which appears to be the joint invention of Messrs. Hering, Abdank-Abakanowicz, d'Arsonval, and Picou. The information obtainable with reference to this new form of cell is somewhat limited, but it appears to be of the horizontal type. Each cell is built up of a number of positive and negative plates placed one above the other, and interleaved with some perforated elastic material, such as indiarubber, celluloid, or other similar substance. The plates are held in position and the elements of like polarity joined together by nuts and bolts made of an inoxidisable alloy of lead. Both elements seem to be composed of the ordinary active materials—viz., peroxide of lead and spongy lead. To increase the active surface, and allow for the free circulation of the electrolyte, each plate is pierced with a large number of holes. Owing to the method of clamping with the nuts and bolts, together with the insertion of the elastic medium, the elements are said to be quite unaffected by slight changes of dimensions, or by the jolting incidental to rough treatment.

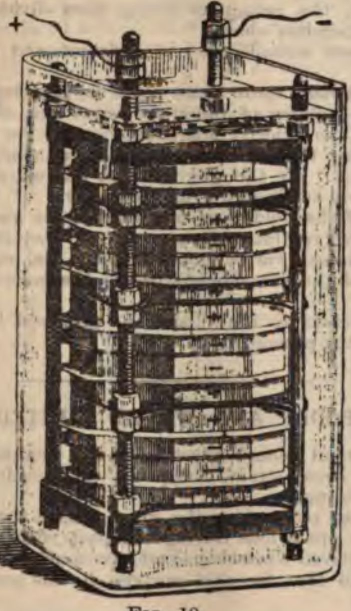

FIG. 18.

Pitkin's Portable Accumulators.—The name of Mr. James Pitkin is well known to most users of portable electric hand lamps. As many of these little lamps are in daily use in various parts of the country, it may not be uninteresting to you to learn something about their construction. The Pitkin elements are very simple, consisting of small cast-metal plates, having an outer raised rim on both its sides, and a number of small tapered pins of the same height studded over its surface. On leaving the chill, the raised pins are tapered outwards, but by a system of rolling or hammering their ends are burred over. This process gives to the pins the shape of a double dovetail, a form well suited to keying in the active material. As the amount of metal in each plate is small, they have been found to hold a larger proportion of active material per pound of plate than the ordinary grid form of element; this only applies to plates of small dimensions. When made up into the form of batteries, suitable, say, for mining purposes, each cell holds either five or seven plates respectively—two positives and three negatives, or three positives and four negatives. The containing cells are of hard rubber, and have a ledge about half an inch from their tops. Thin vulcanite covers are fitted to each cell, and rest on the ledges. Each plate has a projecting lug, which, passing through a hole in the cover, holds them in their allotted position. To keep the plates the requisite distance apart, and to prevent warping, small round vulcanite pins are screwed into the extremities of the positive plates, and are then cut off just sufficient length to slip tightly down between the two negative elements. When finally adjusted in their cells, the lugs of all the plates of the same polarity are lead-burned together. In the centre of each cover, a small vent hole is drilled, which serves both as a vent and for filling-in purposes. Four cells prepared in this way are placed in an oak or teak case. They are then joined up in series by means of lead strips, the vent holes are temporarily plugged up, and the whole is covered in with an acid-proof cement. The lantern usually consists of a deep parabolic reflector, with a bottom flange for fixing purposes. A bevel-edged glass disc, mounted in a metal bezel, acts as a cover and protector, and is held tightly on by a bayonet joint. Within the chamber formed by the reflector, a small incandescent glow lamp is held by two hooked terminals. A small loop is sealed into the top of each lamp. This loop is caught by a spiral spring hook arrangement, fixed at the top of the reflector, which by its pull produces a little tension on the platinum terminals of the lamp, and ensures good contact. A small circular rheostat, having a resistance of about six ohms, is placed in the main circuit between the battery and lamp. A movable arm, pivoted in the centre of the resistance cover carries the current to the rheostat, serving both as a switch to throw the lamp in or out of action, and when turned round on to a small stud to cut the lamp out and complete the circuit direct from the battery to the charging terminals. By this method, whenever the lamp is in action, the charging circuit is incomplete, and therefore all danger arising from short-circuiting or sparking is avoided. This precaution is of some importance, more especially when the lamps are being used in fiery coal mines. The charging terminals are merely small brass studs, sunk in level with the surface of the wood case, with holes drilled in them to receive the charging pins. All the connections are run in grooves made in the wood of the outer case, and are covered in with an insulating cement. The variable resistance is found to be a very useful little adjunct, as, by its means, the potential at the lamp terminals can be nicely adjusted to suit variations in the resistance of different glow lamps; it may also be used to regulate the flow of current when the cells are giving an abnormal E.M.F., which is usually the case immediately after a recharge. A very useful little electric hand lamp of this type, Fig. 19, is now made. It weighs a little less than 2lb., and when fully charged will fully incandesce a small 3·5-volt glow lamp, taking 0·5 ampere for a period of six hours. The four-cell miners' lamp is about 8lb. in weight; it has a capacity of between six and seven ampere-hours, and will run a seven-volt lamp for a period of from 10 to 12 hours.

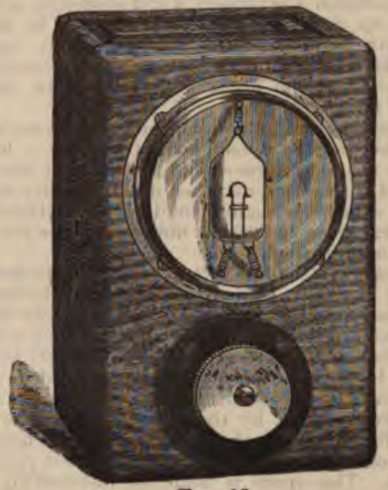

FIG. 19.

Those who are accustomed to work with large accumulators, such, for instance, as the cells now sold for lighting purposes, frequently experience some little difficulty in dealing with cells of so small a capacity and high internal resistance as those to which I have just drawn your attention. As a rule we find that it is almost the usual thing, not only to seriously overcharge them, but to force the current in at such a high rate that the active material is completely blown out of the plates. A few hints as to the most approved method of charging small electric hand lamps may not be out of place. Although the instructions given relate more particularly to the Pitkin form of battery, yet much the same thing applies very nearly to all types of small storage cells.

Charging Small Accumulators.—When joining batteries to the charging source, whether it be dynamo, lighting circuit, or primary battery, care must be taken to have the connecting wires thoroughly clean. In all cases the lead coming from the positive pole of the charging source must be joined to the positive pole of the battery on charge.* This is most important, as a charge in the wrong direction may completely spoil the battery, especially if it be of the "pasted" type. In the case of a four-cell battery having a capacity of about seven ampere-hours, it is found that the charging current should not exceed one ampere for a period of from seven to eight hours. A current strength of 0·7 ampere for a period of 10 to 12 hours, and at a potential of 10 volts, gives, perhaps, the best results. When fully charged, the violent evolution of gas within the cells can be plainly heard; this then is an indication that the charging operation should cease. The generating source may be either a dynamo, primary battery, or thermopile. Six Bunsen or Grove cells, having a capacity of about 20 fluid ounces (one pint) will, with one filling, and when joined up in series, give enough current to effectually recharge a four-cell accumulator whose capacity does not exceed seven ampere-hours. Where the current from a dynamo is available, the secondary battery should be placed in series with one of the glow lamps as used in the installation.† This arrangement gives the best results, as the right E.M.F. and current are secured. When an incandescent lamp cannot be used, it is best to place a small ampere-meter in the circuit, as by its means the amount of current passing at any moment can be read off. To make up for evaporation, a little pure water should be added to the cells from time to time. If the batteries are in daily use, it is a good plan to change the solution about once every four or five weeks. Before doing this, the cells should be fully charged, and should on no account be allowed to remain dry for any length of time.

For export purposes, or if in transit, the batteries are liable to be inverted, or if they are to remain out of use for a lengthened period, the whole of the solution should be removed, the elements thoroughly rinsed with water, and then drained as dry as possible. A good charging solution is made by adding one part of chemically pure sulphuric acid, density 1·85, to nine parts of water. Water free from lime should be used.

Pitkin and Holden's "Ladder" Plate.—Mr. Pitkin and Captain C. Holden have recently devised a form of element which seems to promise extremely well. The elements are made up in this fashion: Shallow cast lead, or lead and antimony troughs are filled in with the oxides of lead and are "formed" in the usual manner. From 15 to 20 of these plates are placed in a suitable metal clamping frame, and are made into one element by having their ends burned together by the blow-pipe flame, or by being treated with molten lead. In the finished elements, both positive and negative, there is a clear liquid space of about $\frac{1}{16}$in. between each little plate. This space is made by interleaving the lead troughs with thin sheets of metal during the running together process, and afterwards removing them. A complete element looks very much like a ladder—hence its name—or a venetian blind when let down.

(*To be continued.*)

COMPANIES' MEETINGS.

ELMORE'S FOREIGN AND COLONIAL PATENT COPPER DEPOSITING COMPANY.

An extraordinary general meeting of the holders of priority and founders' shares in this Company was held at the Cannon-street Hotel on Monday afternoon, for the purpose of passing resolutions altering two of the articles of association.

Sir John H. Morris (chairman) presided, and explained that this meeting was held in consequence of the unanimously expressed wish of the shareholders at the last general meeting in January, that the securities held by the Company should be distributed, which could not be done without altering the articles. The Board had been accused of rushing this matter upon the shareholders, whereas he emphatically stated that whatever action had been taken had emanated from the shareholders themselves. The Board must take up a neutral ground, and do what they could to carry out the wish of the majority. He moved the first resolution cancelling article 109, and invited expressions of opinion from shareholders.

Sir Thomas Farrer entered fully into the position of the holders of priority and founders' shares, he, himself, holding both classes, and stated that he came prepared to vote for the abolition of article 109, to vote for the alteration proposed in article 110, and also to propose an amendment in article 110, which would have the effect of preserving to the priority shareholders their right to the £5 in cash. He intended to propose an amendment that, after the word "premium" in the third line of the 110th clause, the words "in cash" should be inserted, the effect of which would be that whilst at some future time there would be power to divide dividends in shares or in debentures, as well as in cash, yet on this first occasion the Directors would be bound to give to the priority shareholders the cash to which, under the articles of settlement, they were entitled.

Prof. Lambert, of Greenwich, criticised the action of the Board, and was of opinion that though the Elmore process was a good one, there was too much of Stock Exchange work about it. He thought that the compromise which Sir Thomas Farrer had foreshadowed would meet what really appeared to be the desire of the Board, and also the question of justice. The amendment was intended to give the Board the power to distribute any assets, whether shares or debentures, only after the priority holders received the £5 to which they were now fully entitled.

The **Chairman** said he would not go out of his way to answer Prof. Lambert, as he did not want to raise any feeling at all. The Board would accept the amendment, which was a suggestion of his (the Chairman's) to Sir Thomas Farrer. He then put the above resolution, which was seconded by Mr. Jno. MacFarlane, and carried.

The next resolution, which was put from the chair, substituted the following for article 109—viz.: "(109) All dividends shall be payable out of profits only, but such dividends may be declared and paid either in cash or by the distribution of specific assets taken at their par value, and in particular of shares, debentures, or other securities of any other company, or partly in one way and partly in the other." This was carried unanimously.

The **Chairman** then put the third resolution as follows: "Article 110 shall be altered by inserting after the words 'until they have received a return,' the words following—namely, 'either in cash or in shares, debentures, or other securities taken at their par value.'"

To this **Sir Thomas Farrer** proposed an amendment, altering article 110, as follows: "The priority shares shall be entitled to all profits until they have received a return in cash equal to the amount paid on the shares, and in addition 100 per cent. premium, also in cash, before the founders' shares receive any return, and in addition the priority shares shall receive one-fourth of all the surplus profits, the remainder being then divided among the holders of the founders' shares."

Prof. Lambert seconded the amendment, and it was carried unanimously.

Mr. F. L. Rawson made some remarks, pointing out that the interests of the holders of founders' shares were slightly different from those of the priority shareholders, and he was not at all certain that when they had passed that amendment they had done what was correct. He thought the best way out of the difficulty would be to form an Elmore Trust Company.

A meeting of the holders of founders' shares was then held, at which the above resolutions were put *en bloc*, and carried; as also was Sir Thomas Farrer's amendment. And subsequently the general body of the shareholders passed the same resolutions and amendment.

A vote of thanks to the Chairman, proposed by Sir Thomas Farrer, closed the proceedings.

POOLE AND WHITE, LIMITED.

The first annual general meeting of this Company was held at the offices, 58, Bread-street, Cheapside, on Tuesday, Mr. Tryon, chairman, presiding.

The **Chairman** referred to the great success that had attended the Company's operations during the past year, and stated that the time had arrived when they must have much larger works than at present, and that for this purpose it was proposed to issue further capital.

Though the proceedings were private we can state, on good authority, that the shareholders present unanimously adopted the report, and before the close of the meeting it was announced that the greater part of the further capital required was already subscribed.

Weybridge Electric Supply Company, Limited.—Registered by Henry F. Kite, 11, Queen Victoria-street, E.C., with a capital of £15,000 in £5 shares. Object: to carry into effect an agreement made March 20th between the Laing, Wharton, and Down Syndicate, Limited, of the one part, and Percy Mossop, of Thames-street, Weybridge, on behalf of the Company, of the other part, for the acquisition of the Electric Lighting Depot, Weybridge, and to develop and extend the same. Registered without articles of association.

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* The positive pole of a dynamo or other current generator may readily be found by joining two small strips of sheet lead to the wires coming from its terminals, and then immersing them for a few moments in dilute sulphuric acid. The lead attached to the positive pole will quickly turn a rich chocolate colour, while the negative will assume a dark slate tint. Small books of pole-testing papers are made; by tearing a sheet out, and damping it, a red or brown spot will be made by the positive wire when the two terminals are placed upon it. Instruments termed "pole finders" are also made, and most of these rely for the indication either upon the deflection of a magnetic needle, or the chemical decomposition of some electrolysible solution. The positive charging terminal on portable secondary batteries is usually either marked with the plus sign, thus +, or it is painted red.

† Glow lamps as made by the Edison-Swan Company of 50, 75, and 100 volts, usually take currents varying from 0·6 to 1 ampere.

COMPANIES' REPORTS.

ORIENTAL TELEPHONE COMPANY, LIMITED.

Directors: William Addison, Esq. (chairman), B. St. John Ackers, Esq., Henry Grëwing, Esq., Right Hon. G. A. F. Cavendish Bentinck, M.P., Thomas Lloyd, Esq., George Bland Frost, Esq., Alex. B. Chalmers, Esq. (secretary).

Report of the Directors for the year ending 31st December, 1890, to be presented at the eleventh ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, E.C., on Wednesday, the 15th of April, 1891, at 1 o'clock p.m.:

The Directors beg to submit to the shareholders the report and balance-sheet for the year ending 31st December, 1890. The revenue account shows a balance to credit of £8,835. 8s. 11d., which, together with £1,237. 2s. 8d. brought forward from 1889, shows an amount of £10,072. 11s. 7d. available for disposal, which the Directors recommend should be dealt with as follows: To add £2,500 to the reserve fund; to write off £832. 19s. 7d., in reduction of capital expenditure; and to pay a dividend of 2¼ per cent. free of income tax on the total paid-up capital of the Company, which will absorb £4,488. 12s. 3d., leaving £2,250. 19s. 9d. to be carried forward. The shareholders will notice that an alteration has been made in the mode of appropriating the profits. They will have gathered from former reports that the Directors have been endeavouring to come to some arrangement with the holders of vendors' shares for a readjustment of capital account. A conference was held last autumn with one of the largest holders, and at his suggestion the services of an actuary were called in, in order that a disinterested opinion might be obtained of the relative values of the two classes of shares. The actuary having raised a question as to the correct interpretation of the agreements with the vendors relating to the payment of dividends, the point was submitted to counsel, and, in pursuance of the advice received, it has been deemed necessary to declare the dividend ratably on the paid-up capital of the Company, vendors' shares included, and to carry the dividends declared upon the vendors' shares to a separate account, from which it will be distributed to the holders of the ordinary shares until their claims, according to the agreements with the vendors, have been discharged. By this arrangement the deficiency to which those agreements relate has to be made up exclusively out of the dividends upon the vendors' shares, without any obligation on the part of the holders of ordinary shares to bring the dividends on those shares into account for the purpose of making up such deficiency. The distribution now recommended on the total paid-up capital of the Company is equal to £3. 12s. 2d. per cent. on each ordinary share issued prior to February 4th, 1886, as compared with £3 per cent. last year. The Indian companies during the past year show an improvement, the Bengal Telephone Company having paid 5 per cent. against 4½ per cent. the previous year, and the Bombay Company 4 per cent. as against 3 per cent. The increase would have been larger but for the action of the Indian Government, to which the Directors have called attention in previous reports. The Telephone Company of Egypt has declared a dividend of 6 per cent. for the past year on its preferred shares, carrying forward £1,508. 5s. 5d. All the foregoing dividends on the shares held by this Company have been brought as usual into the accounts appended. The branches worked directly by the Company nearly all exhibit an improvement on previous returns, which is partly due to the rise in silver. In order to provide the Telephone Company of Egypt with further working capital for extensions in that country, your Directors have taken up £1,500 of its 6 per cent. debentures. The accounts of the China and Japan Telephone Company have not yet been closed, but they point to a small surplus after paying debenture interest. By a recent Act of Parliament, companies are enabled, at a moderate expense, to amend their memoranda of association. The Directors, whilst they will always bear primarily in mind the original objects of this Company, have come to the conclusion that it is desirable that the powers of its memorandum of association should be extended so as to authorise the supply of electric apparatus and material, and the application of electric power generally. The resolution mentioned in the notice on the back of this report will therefore be submitted for the consideration of the meeting. The retiring Directors at the present meeting are the Right Hon. G. A. F. Cavendish Bentinck, M.P., and Mr. B. St. John Ackers, both of whom being eligible offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and offer themselves for re-election.

REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Dr.	£	s.	d.	£	s.	d.
Expenses in London—						
Directors' fees	1,000	0	0			
Salaries	761	14	0			
Rent	100	0	0			
Office expenses, etc., including telephone subscription	83	13	0			
Stationery, printing, etc.	44	19	6			
Legal expenses	48	1	4			
Postages and telegrams	24	12	5			
Depreciation on office furniture	12	0	0			
Audit fee	52	10	0			
Income tax	34	18	0			
				2,162	8	3
Indian agency expenses				225	2	1
Balance transferred to profit and loss account				8,835	8	11
				£11,222	19	3

Cr.	£	s.	d.
Net profit on working of the Company's exchanges to this date, including dividends and interest on shares and debentures held in subsidiary companies	10,864	12	6
Sundry commissions and interest	347	1	9
Transfer fees	11	5	0
	£11,222	19	2

PROFIT AND LOSS ACCOUNT, 31ST DECEMBER, 1890.

Dr.	£	s.	d.
Amount transferred to reserve fund	2,500	0	0
Amount transferred in reduction of capital expenditure	832	19	7
Balance carried down	6,739	12	0
	£10,072	11	7

Cr.	£	s.	d.	£	s.	d.
Balance of profit and loss, 1889	4,964	7	10			
Less dividend 29th April, 1890	3,727	5	2			
				1,237	2	8
Balance transferred from revenue account, 1890				8,835	8	11
				£10,072	11	7
Balance				£6,739	12	0

BALANCE-SHEET, 31ST DECEMBER, 1890.

Dr.	£	s.	d.	£	s.	d.
Capital authorised—						
300,000 shares of £1 each	300,000	0	0			
Capital issued—						
220,000 shares of £1 each, 11s. called	121,000	0	0			
3,494 shares of £1 each—issued as fully paid	3,494	0	0			
75,000 shares of £1 each—issued to vendors as fully paid	75,000	0	0			
				199,494	0	0
298,494						
Less calls unpaid				2	19	5
				£199,491	0	7
Sundry creditors				347	13	6
Unclaimed dividends				75	2	1
Exchange revenue 1891 subscriptions received for periods beyond 31st December, 1890				1,648	16	7
Reserve fund—						
As per last account	4,500	0	0			
Transferred from profit and loss, 1890	2,500	0	0			
				7,000	0	0
To profit and loss—balance				6,739	12	0
				£215,302	4	9

Cr.	£.	s.	d.	£	s.	d.
Telephone patents, goodwill, etc.	71,000	0	0			
Expenditure on exchanges to date	34,832	19	7			
	105,832	19	7			
Less written off to profit and loss, 1890	832	19	7			
				105,000	0	0
Shares, etc., held in subsidiary companies—						
11,825 preferred shares in Telephone Company of Egypt, Limited, of £5 each 2,875 deferred shares in Telephone Company of Egypt, Limited, of £5 each 14,136 shares in China and Japan Telephone Co., Limited, of £1 each 14,810 shares in Bombay Telephone Company, Limited, of Rs. 25 each 5,516 shares in Bengal Telephone Company, Limited, of Rs. 100 each 50 7 per cent. mortgage debentures of China and Japan Telephone Co., Limited, of £100 each 15 6 per cent. mortgage debentures of Telephone Company of Egypt, Limited, of £100 each Indian Government paper Rs. 1,000				91,937	7	11
Stores on hand—						
At branches	1,993	15	8			
Less reserved for depreciation	500	0	0			
				1,493	15	8
Office furniture	162	0	0			
Less written off to profit and loss, 1890	12	0	0			
				150	0	0
				198,581	3	7
Reserve invested— Deposited with bankers				4,500	0	0
Sundry debtors				7,640	18	9
Cash—						
At Alliance Bank, fixed deposit	3,000	0	0			
" " current account	753	10	11			
In hand with agents abroad	826	11	6			
				4,580	2	5
				£215,302	4	9

PROVISIONAL PATENTS, 1891.

MARCH 31.

5508. **An improved method of electroplating wire.** Thomas Lynch Hemming, 96, New John-street West, Birmingham. (Complete specification).

5518. **Electric and other meters.** Hertha Ayrton and William Edward Ayrton, 7, Horbury-crescent, London.

5530. **An electrical sewing machine.** John Ball, 18, Redshaw-street, Derby.

5539. **Improvements in and relating to street fire alarms, and their combination with telephones.** Francis Elliott Stuart, Volthurst, Twickenham.

5547. **Improvements in apparatus for electrolytic decomposition.** Carl Kellner, 46, Lincoln's-inn-fields, London. (Complete specification).

5548. **Insulated electric conductors.** James Draper Bishop, 97, Newgate-street, London. (Complete specification).

5562. **Improvements in or appertaining to phonographs, graphophones, or the like.** William Phillips Thompson, 6, Lord-street, Liverpool. (Philip Tell Dodge, United States). (Complete specification).

5595. **Improvements in electric heating apparatus.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification).

APRIL 1.

5617. **Improvements in electrical meters or measuring instruments.** William McGeoch, jun., and Andrew Jackson McGeoch, 87, St. Vincent-street, Glasgow.

5637. **Improvements in electric converters.** Reginald Walter Barker, Monument-chambers, King William-street, London. (Moses Gerrish Farmer, United States).

5638. **Improvements in electric batteries.** Walter Ambus Crowdus, Monument-chambers, King William-street, London. (Date applied for under Patents Act, 1883, section 103. 7th October, 1890, being date of application in United States). (Complete specification).

5641. **The improvement of electric arc lamps.** Arthur Ernest Angold, 12, James-grove, Peckham, London.

5656. **Improvements in and relating to electric lamps or lighting apparatus.** Alfred Lyster Shepard, 45, Southampton-buildings, London.

APRIL 2.

5679. **Improvements in or connected with telephones** Richard Steenberg, 3, St. Nicholas-buildings, Newcastle-on-Tyne.

5690. **Improvements in and connected with electric batteries.** Henry Clay Bull, 15, Water-street, Liverpool.

5711. **Improvements in the manufacture of seamless tubes or conduits for electrical and other purposes, and in the apparatus employed therein.** James Raper Thame, 55, Chancery-lane, London.

5712. **Improvements in insulating electrical conductors.** Sydney Pitt, 24, Southampton-buildings, London. (Edward Crawford Davidson, United States).

5713. **Improvements in insulating electrical conductors.** Sydney Pitt, 24, Southampton-buildings, London. (Edward Crawford Davidson, United States).

5714. **Improvements in insulating electrical conductors.** Sydney Pitt, 24, Southampton-buildings, London. (Edward Crawford Davidson, United States).

5715. **Improvements in insulating electrical conductors.** Sydney Pitt, 24, Southampton-buildings, London. (Edward Crawford Davidson, United States).

APRIL 3.

5766. **Improvements in electrical apparatus for use as an electric current meter or as an electromotor.** George Joseph Philpott and Robert Hammond, 46, Lincoln's-inn-fields, London.

5780. **An improved safety device or cut-out for the protection of electric circuits, and of apparatus connected therewith.** John Mabry McMahan, 45, Southampton-buildings, London.

5790. **Improvements in incandescent electric lamps.** Ernest Boehm and Ernest Bailey, 58, Fenchurch-street, London.

APRIL 4.

5794. **Improvements in the application of light, heat, and motive power obtained from electrical circuits to the purposes of advertisement.** Alfred Rene Upward and James Handel Macfarren, Winchester House, Old Broad-street, London.

5795. **Improvements in and connected with electric lighting, and apparatus and appliances therefor.** Philip Henry Williams, Egham, Surrey.

5802. **Improvements in holders for incandescent electric lamps.** William McGeoch, jun., and Andrew Jackson McGeoch, 87, St. Vincent-street, Glasgow.

5824. **Improvements in the manufacture of filaments for electric glow lamps.** James Pitkin, 6, Bream's-buildings, London.

5835. **Improvements in or relating to electrical measuring or indicating instruments.** Adrien Denman Jones, 433, Strand, London.

5834. **Improvements in electrical measuring instruments.** George Wilkinson, 11, Furnival-street, London.

SPECIFICATIONS PUBLISHED.

1890.

3900. **Electrical inductoria.** Pyke and Barnett. 6d.
5409. **Electric arc lamps.** Cappilleri and others. 8d.
5562. **Dynamo electric machines.** Emmott and Rider. 8d.
6802. **Electrical traction.** Waller and Manville. 1s. 1d.
6223. **Galvanic batteries.** Ancizar (Zerda-Beyon). 6d.
6623. **Electric switches.** Warden and Smith. 6d.
6924. **Electric batteries.** Eagar and Milburn. 4d.
7422. **Electric circuit regulator.** Bryan. 6d.
7520. **Signalling on electric circuits** Johnson and Phillips. 4d.
7624. **Electrical transformers.** Kingdon. 8d.
7725. **Electric switches.** Challis and Graham. 6d.
14844. **Electrical connector.** Appleton and Joseph. 8d.
19272A. **Electric soldering irons.** Carpenter. 8d.

1891.

657. **Electric conductors.** Lake (Lord). 6d.
2297. **Electric arc lamps.** Hazeltine. 8d.

CITY NOTES.

Western and Brazilian Telegraph Company.—The receipts for last week were £4,165.

Brazilian Submarine Telegraph Company.—The receipts for the past week were £5,136.

Globe Telegraph and Trust Company.—The Directors have declared an interim dividend of 2s. 6d. per share.

Direct Spanish Telegraph Company.—The receipts for March show a decrease of £452 as compared with the corresponding period.

Cuba Submarine Company.—The estimated receipts for March were £4,000, as compared with £4,016 for the corresponding period of last year.

Eastern Telegraph Company.—The receipts for March were £58,447, as against £58,471 for the same period of 1890, or a decrease of £24.

West India and Panama Company.—The estimated receipts for the half-month ended the 31st March are £3,338, as compared with £3,850 in the corresponding period of 1890.

Great Northern Telegraph Company.—The receipts for March were £22,800, making the total since January 1 £64,400, against £60,200 in the corresponding period of 1890, and £63,000 in 1889.

St. James and Pall Mall Company.—Allotment letters for 10,000 £5 preference shares recently offered have been posted, the shares having been largely over-subscribed by shareholders to whom they were offered.

City and South London Railway.—The receipts for the week ending April 4 were £901, against £702 for the last week of March. The extra traffic on Bank Holiday has made an appreciable difference in the weekly total, which is the highest the Company have yet touched.

Change of Title.—It is announced that the title of the Elmore's Austro-Hungarian Patent Copper Depositing Company, Limited, will in future be Elmore's German and Austro-Hungarian Metal Company, Limited, and that the offices have been removed to 64, Cannon-street.

Companies of the Month.—The following electrical companies have been registered during the past month:

Liverpool and District Pulsion Telephone Company, Limited, £1 shares	£6,100
Weybridge Electric Supply Company, Limited, £5 shares	15,000

Eastern Extension Telegraph Company.—Subject to audit, the accounts of the Company to December 31 show a balance of profit of £106,257, after payment of three interim dividends. The Directors now propose to pay on April 22 the usual dividend of 2s. 6d. per share, besides a bonus of 4s., or 2 per cent., making a total distribution of 7 per cent. for the past year. The balance of £25,007 has been carried to the reserve fund, which now stands at £495,239.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¼
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Bond Street.—The electric light mains are not to be laid in Bond-street until after the London season.

Doncaster.—Great attention has been paid lately in the local press to electric lighting matters at Doncaster.

Boy Messengers. — The Postmaster-General has agreed to license the Boy Messenger Company under the Government monopoly for carrying letters.

French Cables.—We learn that the first submarine cable of French manufacture is now being finished at the works of the Société des Téléphones at Calais.

Toulouse.—The electrical exhibition at Toulouse is to remain open four months from May 15th, and electric lighting and engineering will be made prominent features.

Naval Exhibition.—The Prince of Wales will open the Royal Naval Exhibition on May 2nd. An immense electric light will flash from the top of the model Eddystone lighthouse.

Pitfalls.—An inhabitant of Grafton-street has objected to a pit being made right in front of his premises for the electric light junctions. The companies ought to put them either right or left.

Royal Institution. — Before the Royal Institution, Albemarle-street, on Friday, April 17, at 9 o'clock, Prof. A. W. Rücker, M.A., F.R.S., M.R.I., will read a paper on "Magnetic Rocks."

Telephone Wires at Sevenoaks.—The Sevenoaks Local Board is disturbed by the erection of overhead telephone wires, and the clerk has been instructed to carefully ascertain the Board's powers.

British Association.—Dr. Huggins will deliver the presidential address to the British Association at Cardiff on August 19. It will be seen that the meeting is nearly a month earlier than has been usual.

Toxteth Park.—The Board of Trade have approved of several of the amendments proposed in the Toxteth Park provisional order, but others are not allowed. The lighting is to be available within two years.

Parliamentary.—In the House of Commons, on Tuesday, the London Overhead Wires Bill was ordered to be read a third time; while the Boy Messengers Bill and the West Metropolitan Tramways Bill were read a second time.

Welding.—A company is in process of formation, says the *Financial News*, to acquire a patent owned by Mr. Coffin for the welding of iron by electricity. It is claimed that by this invention iron of 1in. thickness can be welded with 1 h.p.

Megascope.—In the *Scientific American* for April 4 is a fully-illustrated article by Geo. M. Hopkins on a simple attachment to the lantern for optical projection of opaque objects, a piece of apparatus which should be of use to scientific lecturers generally.

Bacup.—The subject of electric light has evidently been exercising the minds of councilmen at Bacup, and the surveyor is reported to have stated a typical shop could be wired for £4. How large, and for how many lamps, are questions that naturally arise.

Haselwander Rotary-Current Motors.—The firm of Lahmeyer and Co., of Frankfort-on-Main, have acquired the patents of Herr Fr. Haselwander relating to electric rotary-phase currents. New motors on the Haselwander system will be exhibited at the forthcoming Frankfort Exhibition.

Turkish Exhibition.—Does any electrical engineer wish to astonish the unspeakable Turk? If so, the opportunity is not wanting, as Mustapha Effendi, Minister of Public Works, it is stated, has induced the Ottoman Government to authorise an exhibition of Turkish products and of manufactures useful to the Turks.

Church Lighting.—The following churches are now lighted by electricity: St. Jude, South Kensington; the Temple Church; Holy Trinity, Sloane-square; also the parish church of Rudstone, East Yorkshire. We notice also that the church of St. Clements, in the Strand, is to be fitted for electric light by Messrs. Veritys.

Norwich.—The Corporation have a hard case against the gas company of Norwich. The illuminating power is low, and the company have given notice that they intend to increase the price from 3s. 4d. to 3s. 10d. per 1,000 cubic feet. The committee advise the Corporation to erect their own gas works. Why not electricity?

Monaco.—A grand reception, followed by a ball, was given at the Palace, Monaco, on Friday evening, by the Prince of Monaco, in honour of the officers of the French and British squadrons at present on that coast. The guests numbered about 300, and the assemblage was a most brilliant one. The Palace was lighted for the first time by electricity.

Dolivo Motors.—The efficiency of the Dolivo rotary-current motors, described this week, is given from recent tests as being from 77 to 82 per cent. The Keys' Electric Company will act as agents for these three-phase motors and the Dolivo rotary-current generally. A test installation, it is hoped, will shortly be on view for English electrical engineers to inspect.

Sutton (Leicester).—The Sutton Local Board are about to consider the advisability of spending nearly £4,000 in gas work extension. It is suggested that the money would be better spent in an incipient electric light station, when the present gas works would be sufficient to supply the remaining for some years to come. In Mansfield the same thing is also mooted.

Barnet.—The Lighting Committee of the Barnet Local Board recommended that £99. 4s. 6d. be paid to Mr. Joel for lighting, and that an arc light be placed near the church instead of two incandescents. After some discussion as to the candle-power—whether 1,000 c.p. or 2,000 c.p.—the recommendation was adopted, the clerk being requested to ascertain the candle-power of the light.

Provisional Orders.—In the House of Commons on April 9, Sir M. Hicks-Beach informed Mr. Spencer Balfour that it was not intended to grant a third provisional order under the Electric Lighting Acts in any district where there were already two companies, unless there was strong reason to suppose that one would be unable to exercise its powers within a reasonable time.

Harrogate.—At the Harrogate Town Council on Monday the borough solicitor laid before the Council certain amendments suggested by the Board of Trade in the provisional order for the borough, which was waiting confirmation by Parliament, and it was resolved that the Council consent to the amendments on the understanding that they are uniform with the provisions of similar orders in other boroughs.

Lighthouses.—Sir James Douglas last Saturday gave an interesting lecture on "Lighthouses," at Dulwich. A very exhaustive description of apparatus was given, and Sir James Douglas dwelt upon the great possibilities of the electric light. Oil and gas, he said, had reached their fullest development, but it was far otherwise with electricity. A further lecture on the extension of fog signalling was promised.

Institution Papers.—At the meeting of the Institution on April 23rd the following papers are down for reading: (1) "On Some Effects of Alternating-Current Flow in Conductors having Capacity and Self-Induction," by Dr. J. A. Fleming, member; and (2) "A Few Calculations on Electrical Shocks from Contact with High-Pressure Conductors," by Major P. Cardew, R.E., member.

Telephones in Ireland.—In answer to Mr. Dickson, on Monday, in the House of Commons, Mr. Raikes said that no public demand for a telephone service between Dublin and Belfast had hitherto been communicated to the Post Office; but if the hon. member had reason to think that there was such a demand, and would communicate with him, he should be glad to give the matter his best consideration.

City Guilds College.—From the report of the City and Guilds Institute about to be issued, it is seen that the Central Institute has 140 students, an increase of 50 per cent. At Finsbury the day scholars numbered 184, and for the special technical evening classes 1,255 tickets were sold, 312 being for apprentices at half fees. The number of papers for the technological examinations was 6,781, against 6,606 in the previous year.

Coast Guard Communication.—Sir Edward Birkbeck has given notice of a resolution in favour of the establishment of telephonic and telegraphic communication on the coasts between all coast guard and signal stations, in order to give facilities for the more speedy employment of lifeboats and rocket apparatus. Where there are no coast guard stations, he proposes that the communication should be with the postal telegraph offices nearest the lifeboat stations.

Dorking.—At the meeting of the Dorking Local Board Mr. Maybank said he had evidence that the electric light would be a greater cost to the ratepayers than gas. He suggested that a committee of the whole Board should be formed to consider the question, and he was convinced they would come to the conclusion that it was far more advisable to retain gas. The expenses of the committee were passed, and the question of the adoption of the electric light deferred to further consideration.

Artistic Fittings.—We have received a pretty catalogue of artistic electric light fittings from Mr. Richard Crittal, of 20, Baker-street. These for the most part are elaborate lightly wrought pendants, electroliers, and brackets, and the same designs are made in wrought iron and in copper and brass. The designs are specially prepared, and bear the evidence of originality, and of adaptation to the light and graceful character of the incandescent lamp. The firm lay themselves out to supply the trade.

Electrical 'Ohms and Main Routes.—We notice that a patentee gives his address as "Volt Hurst." This is electricity at our doors with a vengeance. The idea is attractive, and we might suggest for future use: Ampere Mead, Gower-Bell Grange, Ohm Bank, Faraday House, Dyne Villa, Joule Cottage, Varley View, Siemens-square, Gramme-circus, Paxman-place, Planté-parade, Brush Bungalow, Reiss-row, Edison-end, Thales-terrace, Oliver Lodge, Coulomb-court, Maxwell Heights, Thomson Towers, Ayrton-avenue, Crompton-corner.

Oriental Glass.—For those who wish to have a little extra taste in the ornamental glass globes and shades for electric light (and can pay a correspondingly extra price), the showrooms of the Venice and Murano Glass Company, of St. James-street, offer choicest designs in Oriental glass. Creamy globes, shot with delicate and sparkling colours, fretted and spun and filmed with iridescence, and blown in lovely curves, these electric shades deck the electric light with added beauty, and will delight the taste of the lady of many a high-art mansion shortly to be fitted by electric light.

Leeds.—Alderman Harrison has given notice of the following motion, to be submitted to the Leeds County Council to-day (Friday): "That this Council, as the Local Authority for the borough of Leeds under the Electric Lighting Acts, 1882 and 1888, do hereby consent to the grant by the Board of Trade of a provisional order authorising the Yorkshire House-to-House Electricity Company, Limited, to construct and maintain electric lines and works, and to supply electricity within the borough on such terms and conditions as the Parliamentary Committee may approve."

Rolled Steel Girders.—Messrs. H. J. Skelton and Co., of 12, Lime-street, have sent us their list of steel girders, in mild steel. Any tensile strength can be supplied, from 24 to 32 tons per square inch, the elongation varying according to quality of the steel. The strength being equal in all directions, mild steel is far better than puddled iron, and the loads are 50 per cent. greater, section by section. As rolled steel girders are coming into use for heavy constructions, this list should prove extremely useful. The sizes are arranged with code words for telegraphic orders.

Personal.—As mentioned in our issue of April 3, Mr. A. D. Stevenson has resigned the managership to Messrs. Drake and Gorham to go to South Africa. He writes us from R.M.S. "Athenian," off Lisbon, that he is now on his way to Cape Town to join Mr. H. W. Edlin, M.I.M.E., in partnership. They intend to do a general electric contract business, and will trade under the style of Edlin and Stevenson, with headquarters at 36, Church-street, Cape Town. We wish them the best success, confident that for an energetic firm great fields are open in South Africa for electric light and power.

Colonial Agencies.—Mr. J. F. Albright, of Crompton and Co., is now in Calcutta making arrangements for establishing agencies of the firm in India as well as for developing a system of illumination by electricity in this and other large towns. He is reported as having been remarkably successful in Australia, and, as soon as business circumstances will permit, he will proceed to South Africa, where, among other contracts, the firm has one for lighting up the town of Pretoria for the sum of £25,000. Messrs. Walsh, Lovett, and Co. are appointed the Calcutta agents of Messrs. Crompton and Co.

The London-Paris Telephone.—The Post Office authorities are stated as being very well satisfied with the success which has attended the working of the London-Paris telephone, although they anticipate a considerable development of its use in the future. The average number of messages transmitted from London to Paris daily now exceeds 50, principally Stock Exchange and commercial communications. We understand that one correspondent succeeded in transmitting 300 words for a Press message within three minutes, which was received accurately in Paris.

Killed at Manipur.—Mr. William Babbington Melville, superintendent of Government telegraphs, killed in Manipur, was the eldest son of the late Mr. Andrew Melville, of Dumfries, N.B., and stepson of the Right Hon. Sir Edward Thornton, of Eaton-square. Entering the service more than 20 years ago, he proved a most capable official, zealous and untiring in his work. Mr. Melville married in 1875 Percy Suthua Cameron, eldest daughter of the late Mr. Duncan Grant, of Edinburgh. He had been absent five years, and intended to spend the ensuing summer in Scotland. He had left Manipur in his dhoolie, but was carried back and made captive.

Reflectors.—A small modification may often make a great difference in the practical usefulness of a commercial article. An example is the enamelled reflectors used at Messrs. Ferranti and Co.'s. The old reflectors were opaque at the top, and encircled the incandescent lamp completely; the consequence was the workshop was in darkness save at the lathes and tools themselves. The new reflectors, designed by Mr. Murray, assistant manager, have an opening at the top, which lets out a little of the light, and are also made only to come to the centre of the lamp when attached. The rooms are now in good light all over, while the light on the tools is but little diminished.

Electric Central Station Boilers.—In a big electrical lighting station in Philadelphia there has recently occurred a series of mishaps to the boilers extending over a period of 12 or 14 months, the strongest bolts being inadequate to keep the bends and headers intact. Experts have examined and studied, but without being able to agree upon the cause, and though a coroner's jury, made up of boiler makers and engineers, called to enquire into the cause of an explosion which killed one man and frightfully scalded two others, brought in a verdict against the electrical company, it was unable to explain wherein there had been want of precaution, or point out the safeguards required to prevent a similar occurrence.

Exeter.—At the Exeter City Council the Parliamentary Committee reported that the directors of the electric light company could not consent to the proposal of the Council that the option of purchase of the company's undertaking by the authority should arise at the end of 25 and 32 years, but they were willing, for the sake of disposing of the matter, to accept the Council's suggestion to leave it to the Board of Trade to decide between the parties whether the option shall arise at the end of 25 and 32 years as contended for by the Council, or at the end of 28 and 35 years as proposed by the company. The adoption of the report was carried, it being hoped that by next meeting a satisfactory settlement could be arranged.

The Electric Omnibus in Palace Yard.—On Tuesday afternoon a curious incident was witnessed in Palace-yard, Westminster. About four o'clock an electric omnibus started from the St. Stephen's Club, and carried some dozen members of Parliament round to the members' entrance in Palace-yard. Admiral Mayne was in charge of the omnibus, and among the passengers were Sir William Marriott, Sir Walter Foster, Major Waring, Mr. Majoribanks, and Sir William Walrond. The arrival of the car attracted a large crowd of members, and subsequently a series of trips was made round the neighbouring streets, some hundred members in all availing themselves of the opportunity of testing the practical utility of the omnibus.

County Council Telephones.—Since the passing by the London County Council on the 13th March last of the resolution with reference to proposed telephonic communication between the Council's various pumping and outfall stations and the offices at Spring-gardens, an offer has been received from the National Telephone Company, Limited, to place the Abbey Mills, Barking, Isle of Dogs, Western, Deptford, and Crossness stations in telephonic communication with the chief office at Spring-gardens for the sum of £204. 0s. 3d. per annum on a seven years' agreement. This amount is considerably less than the estimate received from the Post Office authorities, which was £318. 15s., and the committee therefore recommend that no action be taken on the resolution above referred to approving that estimate, and that the offer of the National Telephone Company be accepted.

Riverside Works.—In view of the large number of orders in hand for steam and electric launches, tugs, etc., together with others promised and in course of negotiation, Messrs. Woodhouse and Rawson United, Limited, have resolved to extend their riverside premises, and have therefore just purchased a piece of ground situated close to Kew railway bridge on the Surrey side, with a frontage to the river of between 600ft. and 700ft., the total area being about 2½ acres. For the buildings the necessary plant and machinery to carry out the work alluded to above, arrangements have already been made. The company will also have good dock accommodation in connection with the above, where tugs and barges can safely lie while undergoing any necessary repairs and alterations to machinery, propellers, shafting, or inspection of bottoms. The new works are nearly opposite the two existing yards of the company, and will, it is expected, be in working order in the course of the next two months.

Alverton Electric Tramway.—A supplementary report was appended to the Roads and Works Committee's general report to the Alverton Local Board, with reference to the electric tramway. Colonel Mumby said that the two questions of interest were the mode of traction and the width of the road. The company were anxious to try electric traction if possible. The only way, however, to convey the motive power was by overhead wires, and the committee were unanimous that in such a crowded thoroughfare as Stoke-road, with so much traffic, and as the posts would have to be placed only 50 yards apart, they would be a great obstruction, and therefore declined to sanction their erection. The roadway would also have to be widened in several places, and the width of the footpaths would not allow any part of them being taken up. The only course open to the company was to see if Mr. Abrahams would set back his property, or purchase a strip of land from him, in which case the Board would contribute a reasonable amount in making it a public improvement. Mr. Martin moved, and Colonel Rodney seconded, that this report be adopted, and this was carried.

Studley Royal.—The Marquis of Ripon some time ago entrusted to Mr. Samuel Harrison, of Ripon, the work of preparing a scheme for lighting the hall at Studley Royal with the electric light. It was at first proposed to generate electricity by means of a turbine fixed to the Ripon Corporation water main from Lumley Moor. This plan has been abandoned for a more eligible site, where, with a 19½ft. fall, and 1,000 cubic feet of water per minute 25 b.h.p. could be obtained, capable of maintaining 200 16-c.p. lamps at the hall. The work required is of the simplest description, and, by taking advantage of the natural contour of the ground, the watercourse can be of almost uniform depth, and the dynamo so situated as to be well above the flood line. A turbine of the Hercules type has been selected for the purpose. The distance to the hall is 1,000 yards, and the electricity will be conveyed by a main ⅓in. in diameter, laid bare in an underground culvert to a building known as the old brewery, where a floor will be fixed to hold 56 accumulators, having a capacity to maintain 70 lights for 10 hours. Mr. Harrison calculates that sufficient electricity will be generated to convert the hall into a veritable fairy land, and enough might be provided for the public lighting of the streets of Ripon.

Keynsham (Somerset).—At the last meeting of the Somerset County Council, the report by the County Works Committee stated that Messrs. Parfitt and Son, of Keynsham, engineers, have applied for permission to place poles along the main road passing through Keynsham, for carrying overhead wires from their electric lighting station at Keynsham to other parts of the parish, and the committee recommend that the necessary consent be given, subject to the payment of an annual wayleave rent of 1s. per pole. Lord Temple moved, and Mr. Foxcroft seconded, an amendment that an enquiry be held regarding the question of overhead wires for electric lighting at Keynsham. Mr. Clifton expressed a hope that the recommendation of the committee would be adopted. He presumed that the opposition came from the gas company in Keynsham. The matter had been clearly propounded to the committee, who had had plans and estimates placed before them. The majority of the posts to carry the wires would not be in streets at all. The electric light was greatly appreciated at Keynsham, and places of worship, factories, as well as some of the streets, were lighted by it, much to the delight of the inhabitants. If the wires were placed underground the cost would be about £600 a mile; while overhead wires would cost about a fifth of that sum. The amendment was lost by a large majority, and the recommendation of the committee was adopted.

Leamington.—At a meeting of the Leamington Town Council held on Monday the clerk said that he had received a letter from the Midland Electric Light and Power Company, stating that if any difficulty were experienced in the work of substituting gas for the electric light, they would be ready to continue the electric light until the difficulty was overcome. As, however, it appeared from the Watch Committee's report that the gas had already been substituted, no action was taken in the matter. Mr. Humphries read to the Council a memorial, influentially signed, against the proposal to apply for a provisional order to supply the electric light. It was referred to a committee. The town clerk made a verbal report on the subject of the applications to the Board of Trade by the Midland Electric Lighting Company and the Council for orders to supply the electric light, and explained that, on the recommendation of the inspector, there were several alternatives which the Board were prepared to pursue. He had seen the Board of Trade on the subject, and had explained that the Corporation would not accept an order which involved the condition of purchasing the plant of the electric lighting company. As it appeared that in the case of the company procuring an order there would be provisions incorporated which would protect the public interests, the clerk was instructed to take the necessary steps for withdrawing the application of the Council.

Ganz Alternate - Current Motors.—In Fiume, Austria, four 10-h.p. Ganz alternate-current motors are applied to working passenger lifts, and two others will shortly be added. The International Electrical Company has a central station in Fiume capable of supplying 80,000 watts, of which 30,000 watts are used for transmission of power, and 10,000 watts for lighting the Fiume railway station. In the finished station there will be more than 100 h.p. for motive power, besides current for lighting the docks and all the warehouses alongside. The Ganz motors are of 10 h.p to 12 h.p., very similar to their type "A" alternate-current dynamos. The current is brought in parallel at 2,000 volts, and is transformed down to 50 volts or the motors, which, moreover, are all connected in parallel on the secondary circuit for security in working. The Ganz motors (more fully described in our issue of April 4, 1890) have two pair of brushes, one of which leads in the current, and the other pair serves to short-circuit the magnet coils momentarily before the direction of current is changed, and a by-pass for the extra current is provided through a resistance attached to the brushes. The field intensity thereupon becomes high, and at a certain position of the brushes the incoming current and the extra current have the same direction, and this arrangement is the cause of the building up of force in the motor. When synchronism is established the second pair of brushes is raised. The motors and gearing are of high workmanship, and work well. They have been in use since February, and by their operation here and at Innsbruck these alternate motors have fully demonstrated their utility.

Gas Engine Installation.—The electric lighting installation of the Grimsby Town Hall has been carried out by Messrs. Crossley Bros., Limited, of Manchester. It consists of a specially constructed 16-h.p. nominal "Otto" gas engine, capable of working up to 42 h.p., and fitted with a patent governing arrangement. The dynamo is of horizontal design, and capable of supplying 400 lights of 16 c.p. each. The driving shaft is mounted on large pedestals, and carries a massive balance wheel. The lighting of the hall is as follows: Entrance hall and corridor, four 50-c.p. incandescent lamps; main staircase, nine 16-c.p. lamps fitted on to existing gasolier; upstairs corridors, four clusters of four 16-c.p. lamps. The large assembly-room is lighted by 96 25-c.p. lamps fixed on four special electroliers in wrought iron and brass. The Council-chamber is also fitted with a new electrolier mounted with 24 25-c.p. lamps and 16 8-c.p. ones. The banqueting-hall carries 14 16-c.p. lights on brackets fixed to the walls, 14 16-c.p. lights attached to two existing gasoliers, and one 200-c.p. "Sunbeam" in the centre of the room. The various lavatories, retiring and cloak rooms are fitted with 16-c.p. lights, and the whole are supplied with ornamental opal shades giving an exceedingly pretty effect. The arrangement for controlling switches is very simple and complete. Every room and every cluster of lights in each room is controlled by its own independent switch, and the building as a whole is divided into three portions controlled by switches in the engine-room. Reading instruments both for voltage and ampere current are supplied, and the installation is complete with every modern appliance. The outside of the hall is lighted by two 1,000-c.p. lamps. The cost of gas in the engine for lighting the whole building in this way is given at only 1s. 6d. per hour when all the lights are on, and this consumption is regulated by the engine governor exactly in proportion to the number of lights in use.

Mutual Telephones.—The Mutual Telephone Company, of Manchester, has now been at work some little time, and its operations seem to have met with distinct success. From a copy of a set of testimonials received by the company, we judge that the new lines are looked upon with great favour, and in considering what is said it must be remembered that they refer to a service which was declared to be impossible until after the lapse of the Edison transmitter patent, which, good as it already is, will render the service even better. We extract a letter from a firm well known in the electrical world, Messrs Dorman, Smith, and Co., who say: "We find the system and instruments you have erected in this city extremely satisfactory. The absence of induction and cross-talk on the subscribers' lines, due to complete metallic circuit, is particularly noticeable, and the privacy of conversation a great boon. The operators at the exchange are always on the alert, and a lot of time is saved through not having to ring them up. Our experience of telephones in large cities is that a large exchange cannot be satisfactorily worked on the old or single-wire system, and we are confident that the metallic circuit adopted by you will eventually supersede it." Another, out of many others, is from Messrs.

W. Laverton and Co., who say: "Your instrument has been in use ever since the exchange was opened, and so far nothing but praise has been accorded to it. Conversation is carried on in perfect silence, but the greatest benefit to us is the saving of time in getting taken off one firm and placed in connection with another, which is done almost instantaneously." The Mutual Telephone Company's directors and their energetic engineer, Mr. A. R. Bennett, are certainly to be congratulated upon having pleased so many persons and so thoroughly, while with double the facilities the larger companies usually gain little but anathemas for indistinctness and inattention. It looks at last as if England were really going to have a cheap and efficient telephone service, a thing the original companies have only themselves to blame for not giving universally years ago, and thus assuring for themselves an unassailable position.

The Cambridge Accumulator.—A most commercially and theoretically efficient form of secondary battery cell, says the *Electrical World*, has been invented by Mr. George E. Hatch, of Boston, U.S. In this accumulator a specially-prepared porous earthenware plate takes the place of the leaden grids as the support of the active material, and a thin sheet of lead, or other suitable conductor, is placed between the porous plates and in contact with the active material, which is contained in grooves running horizontally across the porous plates. In this way the weight of the cell is reduced to the minimum weight of the active material and its porous support and the necessary electrodes, which may be of very light weight. The electrodes are made of an alloy which is only slightly subject to electrolytic action, thus securing their durability; and when they require to be exchanged the replacing of them is very easily and inexpensively accomplished. The element, consisting of the set of porous plates carrying the active material and alternate electrodes, is firmly bound together with flexible rubber bands which allow for the expansion and contraction of the active material during charge and discharge; and it will be noted that the possibility of short-circuiting within the cell, either by buckling or by the disintegration and displacement of the active material or in any other manner, is avoided. The earthenware plates are made of a special preparation of clay and are extremely porous and light, as will be evident from the fact that a 7in. square plate ¼in. in thickness absorbs and retains 5oz. of electrolyte, and the porous plates in a single cell of 150 ampere-hours capacity absorb and contain within themselves ⅜ths of a gallon of electrolyte. The curve of a test of three Cambridge cells recently carried out by Mr. Hatch shows the discharge during 10 hours with a starting potential of six volts, falling gradually to five volts in nine hours, and then a sudden drop after eight hours. At the point where the battery rested over night the resistance is indicated as ·045 of an ohm, specific gravity 1·155. The specific gravity at the commencement was 1·185, ampere-hours 95, watt-hours 534.

Electrical Navigation.—The efficiency of the motor in the electric boats at Edinburgh, says Mr. A. R. Bennett, in a paper given before the Royal Scottish Society of Arts, is 85 per cent. if run at its most favourable speed, but this speed was too high for the Union Canal, where 4½ miles, equal to 510 revolutions, is the limit prescribed by the proprietors, the North British Railway Company, to avoid injury to the banks. At this speed the efficiency is on 75 per cent., which becomes 80 per cent. at 6 miles. Propellers of various patterns were tried, and the experiments resulted in the selection of a two-bladed propeller of phosphor-bronze, diameter 19¼in., and a pitch of 14in. This maintains the speed of 4½ miles an hour, with least expenditure of current. A three-bladed propeller created too much work. The accumulators are charged by night by a shunt-wound dynamo, giving, at 750 revolutions, 130 volts and 120 amperes, equal to 15,600 watts, or 20·9 h.p. For charging, the cells are put in series, the four boats being in parallel. The average output of the dynamo, however, is only 11,528 watts, or 15·4 h.p. Each boat takes, therefore, at the rate of 3·8 h.p. After a full day's work six hours' charging are required to bring the sp. g. from 1·172 to 1·2. The weight of each cell is 58lb., containing 15 taper plates, capacity 120 ampere-hours, charging current 30 to 40, discharge up to 40 amperes. It is proposed to put electric boats on the Scotch locks this summer and run at a higher speed. The following data from actual observation were furnished by Mr. Lloyd Parsons, the General Electric Traction Company's electrician in charge of the Edinburgh boats: *Empty boat*—50 cells in series, 107 volts; current at starting, 36·5; at full speed, 34 amperes; in two parallels, 53 volts; at starting, 26 amperes; at half speed, 24 amperes. *Boat fully loaded*—50 cells in series, 107 volts; current at full speed, 41 amperes; in two parallels, 53 volts; at half speed, 29 amperes. The longest run was to Linlithgow and back—40 miles. The E.M.F. on returning stood at 98 volts, or 1·96 volts per cell. Both positive and negative plates were in daily use for 4½ months, and their condition is very satisfactory.

Measuring Radiant Heat.—Prof. Dewar, Jacksonian Professor of Natural Philosophy at Cambridge, in commencing, on Thursday last week, at the Royal Institution (as Fullerian Professor) a lecture course on "Recent Spectroscopic Investigations," spoke of methods of measuring radiant heat. To effect this, it was, he said, necessary to eliminate the transmission of heat by conduction and by convection. He experimentally illustrated the early method of Dulong and Petit, who used a mercury thermometer protected by an ice vessel. The mercury was highly heated to begin with (at 500 it is red hot), and at each minute the loss of heat was noted. This gave the rate of radiation, and showed that there was a greater rate at high temperatures than low. Long afterwards Prof. Draper, using a platinum wire gradually heated up to its fusing point, worked in just the reverse way, noting not the decreasing but the increasing giving off of heat by radiation, and obtained similar results. The modern method, which was used as a "meter" for domestic electric supply, was to note the amount of electric energy given to a wire; and it was known by a law how much light and heat this would give. French chemists had taken melting platinum and melting silver to compare the relation of heat radiated off. Prof. Dewar, using a thermopile instead of a thermometer, showed that platinum gradually heated by a blowpipe up to its melting point gave off heat represented on a conventional scale by 8deg. Silver, tried next, gave but 1deg. The ratio then was one to eight. The melting point of platinum was taken at 1,700deg. Iron, which melts at 1,600, gave 10deg. of heat radiated, two more than platinum. By an arrangement of Prof. Langley's with a spectroscope it was possible to discriminate between radiant heat non-luminous and luminous. Some important practical results had come out of this. For example, candle, oil lamp, and gas jet gave 98 per cent. of heat to only 2 of light. The numbers for arc light were 90 and 10, for magnesium, 85 and 15, sun light 70 and 30, and the Cuban firefly 1 and 99. A great problem in the future of illuminants was to alter the proportions 98 and 2 and 90 and 10, and get as near the firefly's as possible, more light with less heat.

ELECTRIC TRACTION.

III.—METHODS OF WORKING: THE MOST SUITABLE CONDITIONS.

An enormous amount of zeal and energy has been shown throughout the United States in the way of developing electric roads of all kinds, and considerable credit is due accordingly to those who have thus acted as pioneers in effecting the introduction of new and improved methods.

But some little harm has also been done by reason of this very excess of energy and competition in a new field. In order to gain contracts and secure large orders, there has been unmitigated puffing and advertising of so-called "systems" of electric traction named generally after the inventor; and although electrical engineers can easily see through the thin film of novelty or detail which constitutes the "system," neither the travelling public nor—what is more important—the tramway companies have sufficient knowledge or experience to guide themselves as to what particular combination is most suited to the case under consideration.

It is a pity, therefore, that any one method should be offered and upheld as absolutely perfect for all possible cases, when it cannot really be so; and it is a still greater pity that the owners or promoters of such a method should stoop to decry all others as being useless for any purpose whatever.

The truth is, that the question of transmitting electric energy over a distance for tractive purposes falls under exactly the same laws and conditions as the transmission of electric energy for the purposes of artificial illumination. The distribution of power for electric traction differs not one whit from the distribution of power for electric lighting, so far as the fundamental principles are concerned. Yet no one now speaks of employing any particular man's "system" of electric lighting. It is all done by means of alternating or direct currents, which are transmitted in various ways to arc or glow lamps, and therein employed to give light. There is in this no reference to Smith's system being the best, or even to its superiority over Jones's system because of its declared great working efficiency.

We have seen that there are two chief methods of transmitting electric energy for traction purposes, from dynamo-generator to electric motor. These involve respectively the use of secondary batteries or accumulators, and continuous conductors carried along the line of route.

Taking the latter into consideration first, it will be found that, as already remarked, the same conditions apply as in the case of electric lighting. We may transmit the current at either a high pressure (with correspondingly small volume) or a low pressure and great quantity. Moreover, in the employment of both these there may be brought in either the direct current or the alternating.

This gives at least four possible methods of using continuous conductors along the line, which may be tabulated somewhat as follows:

Direct current: (1) High pressure; (2) low pressure.
Alternating currrent: (3) High pressure; (4) low pressure.

But the experience already gained in electric lighting, as well as theoretical reasons, both compel us to this conclusion—that any system of distributing large powers at a low tension is only practicable over a small and limited area. By using currents of electric energy at high tension or pressure, a great saving is effected in the cost of conducting wires or mains, inasmuch as these need not be of the very considerable diameter that becomes necessary when larger currents are employed at a lower pressure. There is also, as a rule, far less waste of energy in the shape of heat in the conductors when transmission is taking place.

With regard to the question of employing alternating currents for electric traction purposes, a primary and fundamental difficulty crops up at once, whether high or low pressures are used. At the time of writing (1890) no really good and efficient alternating-current electric motors exist in the commercial market. Various more or less successful attempts have been and are continually being made in the direction of their employment, and the ultimate satisfactory settlement of this problem is, of course, only a matter of time.

Meanwhile, however, we may very safely discard any treatment of alternating-current distribution at high pressure for tractive uses, inasmuch as we have no motor for alternating currents, and such a system would be therefore like the play of "Hamlet" with the King of Denmark left out. In other respects this method lends itself most admirably to successful distribution; it is essentially one of economical high pressure at the supply stations and in the conducting mains, whilst, by means of the now well-known and highly-efficient transformers, this high pressure may be reduced on any sections of the line wherever trains may be running. The latter require to be supplied with current at a much lower pressure and in greater quantity, not only for purposes of public safety, but also in order to obtain more favourable conditions of working, as well as a standard design for the motors.

Direct currents at high pressure may be used with much more freedom, inasmuch as direct-current motors were known and worked for many years before electric traction began to develop, so that a fund of valuable experience has been acquired in this direction.

But there are still some disadvantages. "Currents of very high tension cannot be conveniently transmitted by the exposed conductors from which the locomotives are supplied, on account of the great leakage of the conductors, and also on account of the danger attending the handling of the apparatus." Again, when speaking of alternating currents at high pressure we found that there were no motors available, whilst admirable means were at hand for reducing the pressure and increasing the quantity at points where work was to be done. And now, in treating of direct currents at high pressure, we find the converse of this: there are excellent direct-current motors to be had, but, unfortunately, no equally good transformers or appliances for reducing the pressure as desired. Direct-current transformers certainly exist, but they necessitate considerable complications, and are by no means so efficient as those for alternating currents.

Numerous appliances and inventions have been devised for supplying electric railway or tramway lines with currents of high pressure in the main wires or conductors, which are transformed in one or other of various ways into currents of moderate pressure in the branch wires or secondary conductors from which locomotives receive their supply as they pass along the line.

Perhaps, however, the following is the simplest, and expresses best what can be effected in the direction of economical and efficient working. The supply of electric energy is brought at high pressure from the supply station along suitable conductors of small diameter, and is then passed through the transforming appliances into a secondary conductor of much larger size running alongside the line, from which the motors draw their supply of electricity.

This secondary conductor is divided into sections or successive insulated lengths, each arranged to supply the motor as it passes along the line; and each of these sections is connected to the primary or main conductor, which extends continuously the whole length necessary to supply the last of the secondary sections. The transforming appliances, according to one arrangement of this method, consist of successive secondary batteries or accumulators introduced into the primary conductor, one for each of the sections in the secondary conductor. Each of these batteries is such that it reduces the pressure in the primary or high-tension conductor down to that which is desired for the proper working of the motors on the secondary conductor circuit, whilst at the same time raising the current in quantity. Thus a current of 50 amperes in the primary conductor from the supply station may be supplied at a pressure of 2,000 volts; the battery—acting as a transformer—passes on this current to the secondary conductor (from which the motors are worked) at the reduced pressure of, say, 400 volts, the current increasing in proportion to 250 amperes.

According to another arrangement, there are introduced into the primary conductor a number of successive reproducing or transforming machines—that is to say, electromotors worked by the primary current and operating dynamo-generators, which produce currents at a pressure suited to the requirements of the secondary conductor and the motors worked from it. In some portions of the line one appliance may be preferable to another; for example, in providing for a section having a steep gradient, a battery may be arranged in the primary conductor to give a large current in the secondary conductor for working the motors on that section, or a reproducing machine may be employed to give the desired current.

In all traction systems, according as high or low pressure systems are used, there are two courses to adopt. The motors operated along the line may be fed either:

1. In *series*—that is, tandem fashion, one after the other; the same current passing through all the motors, or

2. In *parallel*, in which case the current of electric energy is split up amongst the motors in strict accordance with the work they are doing at the time.

When the motors are run in series a high pressure is required, varying in exact proportion to the number of motors at work. Thns, if each motor needs a pressure of 100 volts to drive it, and if there is a maximum number of 10 motors at work at any given moment, then a total pressure of 1,000 volts must be provided, although, of course, the current will not always be drawn from the supply dynamo at this pressure. There may be only one motor working at any moment, in which instance the pressure will be 100 volts; it varies, therefore, between 1,000 volts and zero in such a case, according as there are 10 motors or none at work. The quantity of current, as measured in amperes, remains the same throughout.

The converse of these conditions obtains when the motors are run in parallel: the pressure is kept constant, say, at 100 or 500 volts, or whatever may be decided upon; whilst the current, measured in amperes, varies in proportion to the number of motors at work.

In both cases, therefore, the supply dynamo is depended upon for regulating the electric energy sent out along the line circuit, in strict accordance with the demands made on it at any moment by the motors; and as these demands vary most incessantly, perhaps, from zero up to the maximum capacity of the dynamo, it will be seen at once how elastic, efficient, and economical the whole system of electric traction becomes, inasmuch as the prime motor and supply dynamo give out exactly the amount of power required, and no more. The same conditions apply to traction methods in this respect as are already found to rule in the case of electric lighting from central stations.

Series working will be found most economical of employment in certain places and under particular circumstances; at other times it becomes much more advisable to operate lines on the parallel system. Both methods have great advantages; both have a few drawbacks when compared with one another. Both, however, can fill separate spheres of work with every possible satisfaction, and it is impossible to give preference to or institute any final comparison between methods which ought to work side by side, each complementing the other.

As for deciding which of these should be adopted for any particular line, the whole circumstances and conditions must be examined and collated; these, of course, will vary for each line, and hence the impossibility of advising one system to be always used. Much depends on the position of the central station; if this can be situated in the centre of a network of lines on which the traffic is very heavy, then, perhaps—other things being equal—the parallel system may be most suitably employed. If, on the other hand, the supply station—owing to such considerations as cheap sites, proximity to fuel, etc.—must be erected at either end of a long line, and if the traffic be not so frequent as in the former case, then the system of series working should receive most attention. Again it will be seen how exactly similar are the conditions herein obtaining to those met with in electric lighting from supply stations.

We may now pass on from the continuous-conductor method of working electric traction lines to the self-contained or independent systems in which are employed secondary batteries, or accumulators, placed on the motor car or train itself. These batteries are periodically recharged at the supply station.

There are some extremely good points about this battery method, apart from the advantages mentioned (see last article), which deserve special mention; they concern principally the supply station itself, and from that have an important bearing upon the economical working of the line.

It has already been stated that in using the battery system we are enabled to fix the supply station anywhere along the line—that is, at the most suitable position so far as cheap sites and handy fuel are concerned.

If this position happens also to be near a high-class residential district, the station equipment of engines and generator dynamos may be worked to their utmost output and efficiency by supplying current for electric light in the neighbouring houses.

This current, of course, would only be available during certain portions of the day or night, when it is not required for charging the traction car batteries, and it would, therefore, have to be stored up in sets of accumulators at the supply stations or in sub-stations in the districts outside.

The generating plant would, of course, require to be somewhat larger than might be found necessary for charging the car batteries alone, but the greatly increased revenue brought in from the houselights would far more than recoup the additional outlay upon larger engines and dynamos with additional accumulators.

It offers, in effect, the possibility of starting a central electric light station with an expense of only a fractional sum upon what are usually the most costly necessaries—land, buildings, engines, and dynamos—the other items of course remaining the same.

In addition to this, it is very often the case that power may be obtained at such a supply station in an exceedingly cheap fashion, by setting up some improved form or other of the well-known "dust" and refuse destructor. Amidst any densely-populated districts, there are not only profitable openings for the employment of such appliances, but our increasing powers of civilisation will, for sanitary reasons, undoubtedly demand their use in a harmless and innocuous form.

Already some experiments of value have been made in this direction, and useful results obtained; further trials will doubtless show what may be expected from a simple and convenient system of killing several birds with one stone—viz., getting rid of "matter in the wrong place"—by utilising it for the production of electric energy to light our houses or streets, and propel public vehicles along tram or railways.

(To be continued.)

NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.*

BY W. B. ESSON, MEMBER.

(Concluded from page 363.)

But whether it is possible to reduce the gap to an extent which, with an increased number of poles, will lead to a less costly construction, is a question which for machines of moderate dimensions must receive careful consideration in each individual case. The answer depends upon how much larger the gap has to be to prevent sparking in the case of two poles only than is requisite to accommodate the conductors and allow the necessary clearance. If the difference is considerable, it may pay better to add poles, and reduce the gaps that way, than to do the same thing by diminishing the pole angle or increasing the induction, or both. The question, it appears, is answered in different ways by different people. It is somewhat interesting to note, for instance, that one engineer, distinguished for the past six years as an ardent advocate of multipolar machines, has, after reducing from six poles to four, lately arrived at two, while another has jumped straight away from two to six without a halt at the intermediate number.

But when we come to machines of a certain size there is undoubtedly a gain in employing more than two poles, while very large machines become impossible of construction with two poles only. Consider the case of a two-pole armature of 60 centimetres diameter. Assuming the induction in the gap to be 5,000 C.G.S. lines per square centimetre, and the pole angle 130deg., our calculations show that the length of air gap would require to be 3·24 centimetres. This is some 40 per cent. in excess of the requirements of conductors and clearance; so, if the gap is reduced until it just allows of the requisite clearance, the induction must be increased from 5,000 to 7,000. Keeping the output of the machine the same, however, we can reduce the diameter of the armature to 54 centimetres, and work with an induction in the gap of 6,500. Observe, the magnetising force spent in the gap has now been reduced by about 7 per cent., but the total field through the armature has been increased by 15 per cent., and the induction in the armature per square centimetre by more than 25 per ceut. If we retain the same section of iron in the fields, it may be assumed then that about the same total magnetising force is required, whether the machine has an armature 60 centimetres diameter, with a gap induction of 5,000 C.G.S. units, or one 54 centimetres diameter, with a gap induction of 6,500. The latter might turn out to be impossible, owing to the greater heating of the armature core; any way, what I am attempting to show now is, that by pressing up the induction with a view of reducing the gap, little, if any, advantage is obtained. But by increasing the number of poles, and reducing the gap in that way, we effect, without increasing the gap induction, a marked economy. As it is unnecessary to go into a mass of figures to prove what each can readily prove for himself from the data already before you, I will just give here the results. If we substitute for the two-pole armature of 60 or 54 centimetres diameter and 90 centimetres long a four-pole one of 84 centimetres diameter and 45 centimetres long, with a gap induction of 5,000, we require for the magnetising coils while working at the same sparking limit, and with the same efficiency, rather under 70 per cent. of the copper on the two-pole field. When to the saving in copper there is added the saving in iron, there will be, after the extra labour is debited against the four-pole machine, a considerable balance in its favour. But to go beyond four poles in this case would be a mistake. Increasing the poles always results in an actual increase of copper, unless at the same time the power spent in the gap

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* Paper read before the Institution of Electrical Engineers, April 9, 1891.

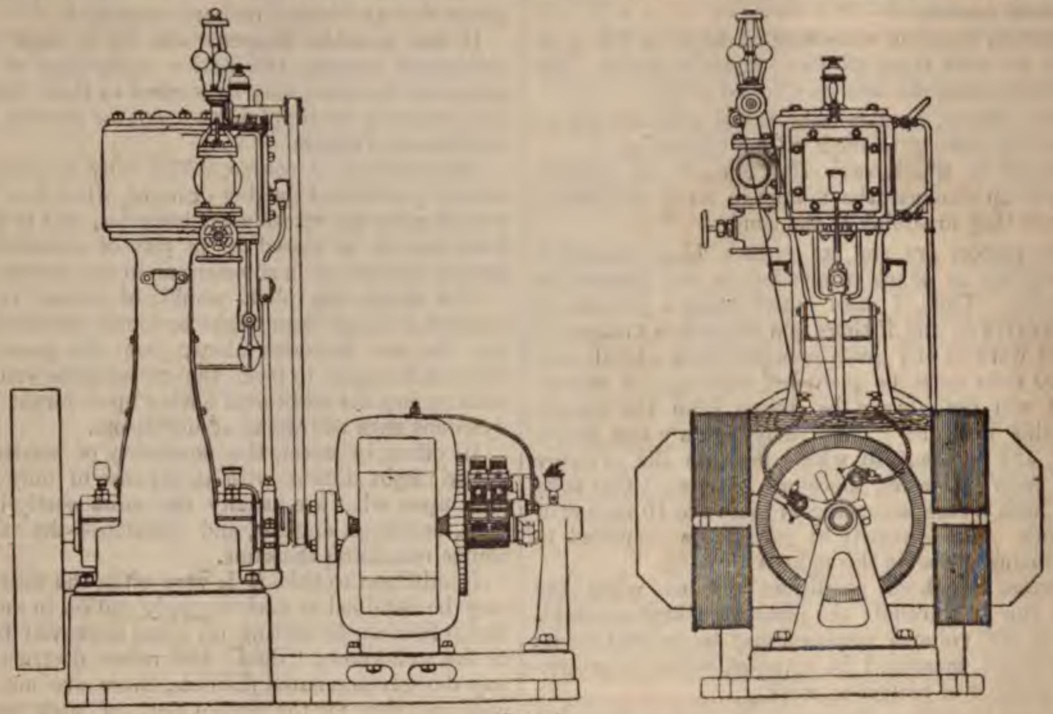

FIG. 5.

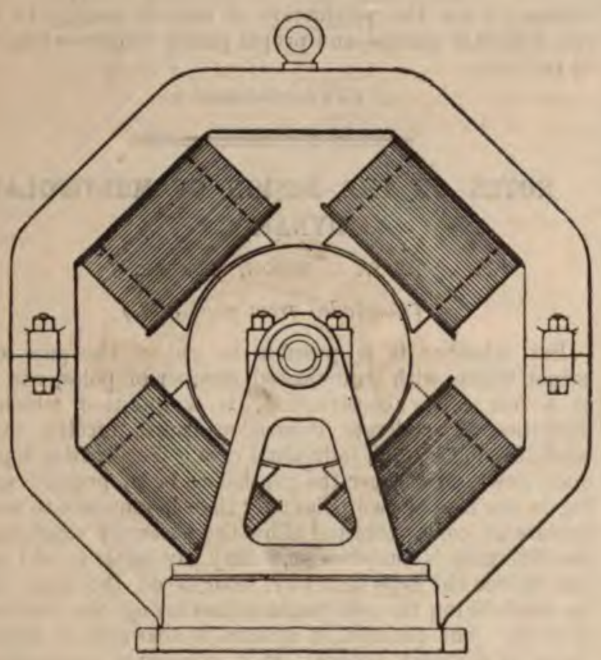

FIG. 6.

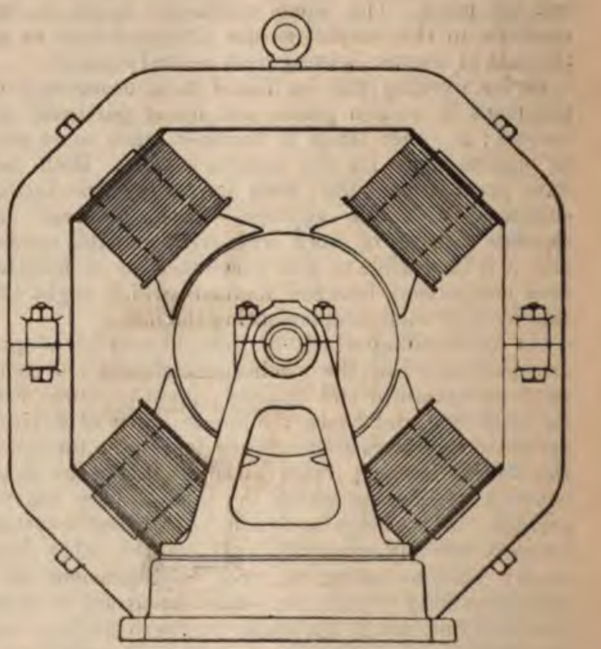

FIG. 7.

is reduced, and this latter must be effected without reducing the thickness of the armature winding. The economy shown above is simply due to the fact that in a two-pole machine of the dimensions specified the gap necessary for the prevention of sparking must be much larger than the conductors require unless pressed up to a high induction. If with four poles the gap is still larger than necessary, we go to six poles, and so on. But when we arrive at a point where increasing the number admits of no reduction in the gap, we go no farther. It may be mentioned, however, that even in sizes where a four-pole construction showed no actual economy in first cost, it might still be preferable to the two-pole on account of its symmetrical field and the absence of magnetic pull.

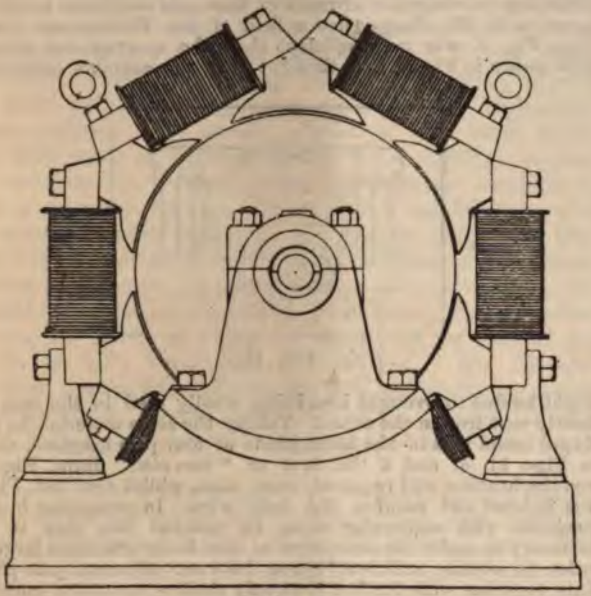
FIG. 8.

Having discussed the design of multipolar machines as influenced by both theory and practice, it remains to conclude this communication by calling attention to some of the ordinary forms of multipolar fields. The double wrought-iron horseshoe, Fig. 4, is not very frequently used, being rather costly; but a similar machine with magnets of cast iron, lately made by my firm for the National Line s.s. "America," is shown in Fig. 5. The armature core in this case was formed by winding square annealed-iron wires on a gunmetal flanged cylinder. The winding was of the Gramme type, and the machine was coupled direct to an inverted engine, as shown in the figure. This design, introduced by Gramme in 1869, generally gives place to the arrangement shown in Fig. 6, a form designed by the same inventor in 1885, and since adopted for cylinder-wound armatures by many makers, including Mr. Jaspar, in Belgium; Mr. Brown, of the Oerlikon Works, in Switzerland; and Messrs. Paterson and Cooper, in England. Lately Mr. Kapp has used the same form for six and eight pole machines with drum armatures. The magnets and octagonal yoke in Fig. 6 are of cast iron, in two pieces, the lower limbs, the bottom half of the yoke-ring, and bed-plate being one casting, and the top limbs and upper part of the yoke being another. Fig. 7 represents a similar field in which the magnet cores are of wrought iron, fitted with cast-iron pole-pieces, as used by Mr. Kapp in the machines above mentioned. The decision as to whether cast iron or wrought iron should be used is arrived at in a very simple manner—by comparing the excess of copper required on one hand with the extra machining required on the other.

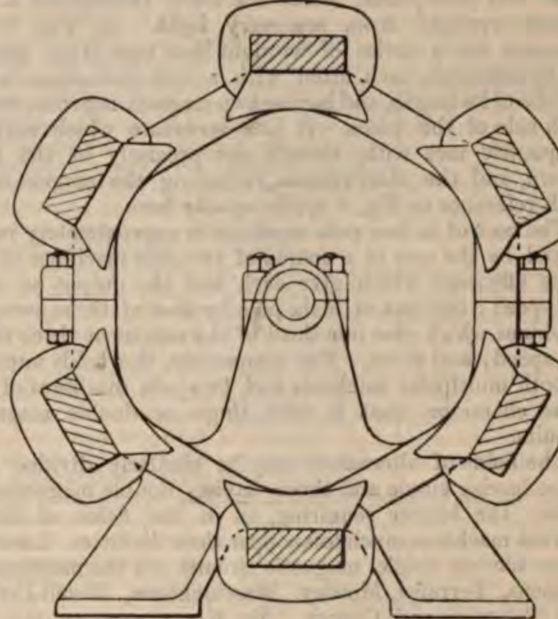
FIG. 9.

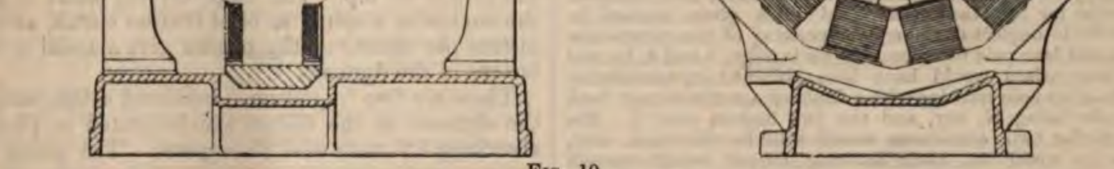
FIG. 10.

It will be observed that in the designs, Figs. 6 and 7, the yokes are considerably longer than those shown in Fig. 4; and the weight of the former, if made of the same material, would be, roughly, twice that of the latter, though even the complete magnet system would be but 75 per cent. of the weight of Fig. 3. The yokes being of cast iron, however, the system really comes about 20 per cent. heavier than Fig. 3; the less expensive character of the material compensating, of course, for the increased weight.

All these are examples of single magnetic circuits, where the lines of force from each pole remain undivided in their paths through the magnetising coils; but in Figs. 8 and 9 are shown examples of double magnetic circuits, in which the lines from each pole take two paths through separate coils. Fig. 8 is a type of magnet used by Sautter-Lemmonier, of

Paris, for Gramme-wound armatures, and by Cuenod-Sautter, of Geneva, for armatures having a Siemens winding as modified by Thury. The magnetising coils are wound upon the parts of the system constituting in Fig. 7 the yokes, and a greater amount of copper is in consequence required. It looks at first sight as if the weight of copper were not very different in the two types, but in this respect appearances are deceptive, for as a matter of fact the field of a four-pole machine made to Fig. 8 would require about 125 per cent. more copper than if made according to Fig. 7. It will be observed, however, that the magnet cores and pole-pieces, which are made throughout of the softest wrought iron, are very light. In Fig. 9 the magnets are a series of wrought-iron bars lying parallel to the armature, each fitted with a cast pole-piece in the middle of its length, and having two magnetising coils, one on each side of this piece. It is a structure which may be frequently met with, though not precisely in the form shown, and the observations regarding the copper made with reference to Fig. 8 apply equally here.

The cost of a four-pole machine is approximately represented by the cost of a couple of two-pole machines of the same efficiency which give each half the output at twice the speed; the cost of a six-pole by that of three two-pole machines which give one-third of the output at three times the speed; and so on. For comparison, the fields must be in both multipolar machines and two-pole machines of the same character—that is, with single or double magnetic circuits.

The fields of alternators may be similarly divided into those having single and those having double magnetic circuits; the former requiring, as in the fields of direct-current machines, much less copper than the latter. Amongst those having single magnetic circuits are the machines of Siemens, Ferranti, Mordey, Westinghouse, Elwell-Parker, and Paterson and Cooper. Mr. Kapp possesses the distinction of having the only alternator with double magnetic circuits. The "Phœnix" alternator, shown in Fig. 10, possesses some features which may be of interest as illustrating the way in which the commercial aspect of designing has to be considered. The yoke-ring is of cast iron, but the magnets are of tooled wrought iron, shaped as shown. If the magnets had a breadth equal all the way up to the length of the armature core, they might as well have been of cast iron, for the little advantage consequent on the reduction of copper obtained by narrowing them would not have paid for the extra work in tooling wrought iron. But when we reduce the breadth where the magnetising coils are, as shown, we at once diminish the copper on the fields by 60 per cent., greatly reduce the leakage area, and get a good balance after paying for extra tooling. The machine, as will be seen, has 12 radial magnets, and there are on the armature six flat coils, each equal to three times the width of the magnet cores, and laid on the periphery with a space equal to the core between them.

The length of the paper prohibits me from dealing with many special types of machine, to which, however, all the reasoning here used may be applied without difficulty.

DISCUSSION.—*Authorised Abstract.*

Prof. S. P. Thompson said he regretted that Mr. Esson had used the word "volume" for something which was not of the nature of *volume*, and he thought that the meaning assigned to it was not the *ampere-turns* on the armature, but twice that number. The formulæ for the theoretical load limit given seemed incorrect owing to neglect of leakage. Speaking of the comparison of the two and four pole machines, shown in Figs. 3 and 4, he said a better comparison would have been obtained by considering Fig. 4 to be a too-pole machine with a double magnetic circuit, both the top poles being N, say, and the two bottom ones S. The surfaces of the two armatures would still be the same, and, so far as he could see, their limiting output would remain unaltered. It was thus not a question of the number of poles, but of the number of magnetic circuits. Again, relations between the "volume of current" and the diameters of ring and drum armatures were given, but no mention as to whether these were intended to apply to machines with single or double magnetic circuits was made. In his (Prof. Thompson's) opinion it would have been better to distinguish between the two types, for he believed the proportions should be different, and that an armature working in a double-circuit field could safely carry a greater current that when in the field of a single magnet. Referring to "cross-induction," he remarked that some years ago he suggested that pole-pieces should be laminated, or have air spaces parallel to the lines of force, in order to counteract the weakening of the field near the trailing horns. As regards the proportions of iron and copper in the magnets of direct and alternate current multipolar dynamos, he thought a more modern type of alternator than that shown in Fig. 2 should have been chosen, for in that the amount of copper was prodigous. In conclusion, he thanked the author for the many good things contained in the paper, and said the data there given would be very useful in designing machines.

Mr. Kapp, speaking of the laminated pole-pieces mentioned by Dr. Thompson, said Mr Joel adopted a similar plan in 1885 with the idea of getting more corners on his magnet, and consequently obtaining a greater magnetic pull. He himself had also designed multipolar machines with a deep slot in the middle of each pole-piece, and found that the armature reactions were halved thereby. Referring to magnetic circuits of four-pole machines, he did not agree with Mr. Esson that a field of the Elphinstone-Vincent type, Fig. 4, was more efficient than the symmetrical Gramme field shown in Fig. 6, and thought that the author's conclusions might be due to wrought iron being wholly used in the one, and mostly cast iron in the other. Taking the same material, he (Mr. Kapp) found that of the three kinds of four-pole magnets, shown in Figs. 11, 4, and 6 the first or "iron-clad" form, Fig. 11, was the heaviest and required most wire, whilst the last, Fig. 6, was lightest and requires the least wire. In comparing bi-polar machines with multipolar ones, he pointed out that it was necessary to make the armatures of the latter machines larger in order to obtain sufficient space between adjacent pole-pieces. This, together with the fact that only shallow armature cores are needed, makes the ventilation of multipolar machines very much better than bi-polar ones. This point, he thought, had been overlooked by the author. Although Mr. Esson's formula for the "volume of current" carried by armatures agreed fairly well for well-designed machines, it must, he said, not be used indiscriminately, and that if a larger current be made with a view to increasing the "volume" of current, the field magnets must also be increased.

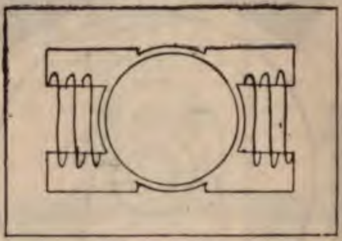

FIG. 11.

Mr. F. V. Andersen remarked that Mr. Esson's formulæ for the load which could be safely carried by armatures without sparking did not include the number of commutator segments. He thought that increasing the number of such segments tended to diminish sparking, and enquired whether sparking could not be prevented by this means?

The further discussion of the paper was adjourned to the 16th inst.

ELECTRIC PUMPING PLANT AT NUNNERY COLLIERY.

The electric plant which has recently been installed at the Nunnery Colliery, Sheffield, consists of an Immisch dynamo and motor, the current being transmitted from the former to the latter, by means of a cable, a distance of 3,500 yards. The dynamo is compound wound and gives 22 amperes at 520 volts, the speed being 880 revolutions. It is driven by the fan engine, the speed being obtained by means of a countershaft with pulleys, driving two leather link belts. The power required to actuate the dynamo at full load is 22 h.p. The large driving shaft is geared to the engine by a spiral form of friction clutch, and 37 revolutions per minute of the engine give a speed of 880 revolutions of the dynamo.

There are two $^7/_{16}$ bitumen-insulated cables leading from the dynamo to the motor, which is rated at 16 h.p. when absorbing 525 volts and 25 amperes. The power from the underground motor is transmitted by means of a leather link belt on to a countershaft, which has spur gearing of 5½ to 1 on the pump shaft. The pump is a three-throw ram pump, and delivers 50 gallons of water per minute through 2,000 yards of 4in. pipes with a head of 385ft.; this being equal to 6 h.p. in the water, neglecting friction in the pipes. The cables are taken down the shaft in pipes, and are fixed to the props in the pit with wooden clamps. They are quite slack, so as to enable them to give way in case of a fall of roof,

THE OERLIKON WORKS, ZURICH.

In connection with the proposed transmission of 300 h.p. from Lauffen to Frankfort by means of an alternating current at 30,000 volts tension, a description of the Oerlikon Works may be of interest.

The factory itself is a large engineering works, employing nearly 1,000 men, situated at Oerlikon, a village about three miles from Zurich on the main railway line. One of the chief proprietors is Colonel P. E. Huber, who is an engineer by profession and acts as managing director. Besides constructing excellent lathes, drilling machines, cranes, etc., the well-known porcelain cylinder flour mills of M. Wegmann are here manufactured, and of late years also shells, fuses, etc., for the Swiss Government, besides the now well-known dynamos and vertical high-speed steam engines. The works consist of one main building, with lines of shafting driven by a 350-h.p. engine, an iron foundry, a testing-room for electric machinery, with a separate 100-h.p. engine, and a smaller one, and numerous detached buildings for various purposes. One large room is devoted entirely to the winding of armatures, another building to the manufacture of accumulators, etc. Several of these are supplied with power from electromotors, the utility of which for home use as well as for clients is fully recognised at Oerlikon. The Bülach-Oerlikon transmission of 600 h.p. into the works by means of alternating current at 25,000 volts tension is one proof of this. We hope soon to hear this has been set in action.

Another proof is the electric tram, which, originally started to run round the works for experiment, is now used for pushing the loaded trucks on to the railway line. The works are lit by about 80 arc lamps of various patterns, and several hundred incandescent lamps, fed partly from two 500-ampere 70-volt machines, direct coupled to a vertical steam engine, and partly from other machines and accumulators that have been added to meet the constantly increasing demand.

For the last four or five years the electrical department has been under the management of Mr. C. E. L. Brown, the son of Mr. Charles Brown, a well-known engineer of English nationality, who has settled on the Continent. Realising what a field Switzerland presented for the electric transmission of power, by reason of the numerous waterfalls scattered about the country, Mr. Brown had the courage and skill to put the theories of Kapp into execution on a practical scale. In the Kriegstettin-Solothurn transmission of 50 h.p. over a distance of over five miles he obtained 75 per cent. useful return, as was proved by the tests of an independent commission, who were allowed every facility for making trials. After this, orders for dynamos for the transmission of power, for lighting, and for metallurgical purposes flowed in from all parts of the world, including England and America. Details of installations made by the Oerlikon Works have frequently been given in our pages, and we need not refer to them here, except to say the dynamos are all characterised by great solidity of construction and good workmanship. They are of excellent design, and show no trace whatever of that unfitness for rough usage which Englishmen once used to associate with machinery of continental manufacture.

There are, however, certain limits to the successful transmission of power by means of continuous-current dynamos, and the fact that the power cannot be distributed is another great disadvantage. This matter has been fully gone into by Mr. Kapp in his recent Cantor lectures. Having arrived at the limit of useful work with continuous currents, Mr. Brown is now devoting his attention to rotary alternating currents, working in conjunction with Mr. Dobrowolski, of the Allgemeine Gesellschaft of Berlin, whose paper on these currents we are giving in the current numbers.

The Oerlikon Works have become licensees of the three-phase motor system patented by Mr. Dobrowolski, so that the practical value of this latest development will soon be demonstrated in practical application.

We may add, with reference to the success of these works, that it is always a puzzle to us how Switzerland, a land without coal, iron, or copper, can compete with all the world in machinery construction, especially as the workmen are very fairly paid. We do not know if it is due to the absence of strikes, or lawsuits, or watered capital, or because the directors begin work at 7.30 a.m.

A NEW FORM OF MEGOHM RESISTANCE.*

BY RICHARD W. DAVIDS.

The instrument of which this paper treats is not new entirely, but has been used some years in England to a limited extent, so that the title refers mainly to its introduction in this country.

It is designed to take the place, at a small cost, of expensive and cumbersome wire resistances having approximately equal values, or the use of varying shunts, different E.M.F.'s, and the wire resistances in ordinary use in measuring commercially the insulation resistance of cables, air lines, etc., by means of proportional deflections on a sensitive galvanometer. The resistance of these boxes varies from one to five megohms, although these limits are not necessary, so that they may be had approximating the resistance which are met in everyday use.

So far as it is known to the writer the construction is as follows: On an etched glass plate of some 4in. by 6in. a pencil line is drawn resembling a sinusoid, experience teaching to a small degree, however, its breadth and length. The pencil used is probably an ordinary lead, or rather graphite pencil, of a hardness found empirically to give the best results. This line is burnt into the plate most likely with the use of a flux; this operation has to be done slowly and takes some time. After a rough test for resistance to find if it is within the range sought, it is mounted in a block on springs to take up jars and make connection with the ordinary tall binding posts of apparatus needing high insulation.

There is no attempt made at adjusting these boxes, the plates are made and measured, any that are too high or too low being rejected, the surfaces ground off and made over again. In this way a comparatively cheap instrument is obtained. They are not laboratory instruments, but designed to meet the want of everyday line and cable testing, where speed and not great accuracy is desirable.

A somewhat similar instrument for laboratory work consists of a plate of unglazed porcelain, or even a sheet of paper, having pencil marks made on it, connection being made by means of springs resting on these marks. The objection found in these forms is that a breath of wind or jar may so change the contacts of the graphite particles as to seriously alter the resistance.

Some 20 of these boxes were brought the writer for calibration, and the question arose as to the best way to measure them accurately and quickly. The first method tried was with a Thomson reflecting galvanometer, finding its constant with the one-ninety-ninth shunt, and sufficient resistance to give nearly the same deflection as with the meg and no shunt, using in both cases 40 cells of chloride of silver battery.

As checks, other measurements were made using no shunts, and varying the E.M.F.; and also the bridge method. It is fortunate there were two boxes of 100,000 ohms each at hand, as the second and third terms of the proportion; and with these calibrated in terms of a standard box which was the first term, it was possible to determine accurately the meg, the fourth term.

It was disapppointing to find the checks did not check, those figures obtained with the shunt method being much out. As the shunts were found to be practically correct, it could not be due to them, and on repeating the measurement with accumulators the discrepancy disappeared, showing that the silver battery, even with small currents, polarises. Everything seemed to go nicely now, having perfect faith in the bridge method, when, in order to get a closer balance, the battery was increased considerably, with the disheartening result that it appeared the resistance depended on the current used. This change was very small, less than 1 per cent., and negligible in practice, but it seems to show that with such small currents as $\frac{1}{1000000}$ of an ampere, appreciable change takes place, perhaps from heat, directly or indirectly.

As an interesting point, the heat developed in such a box would raise one-sixteenth of a grain of water 1deg. C in one minute. Supposing the resistance to be due to the imperfect contact of two adjacent molecules of carbon, the rise in temperature given could scarcely be enough to change the resistance.

It has been stated that change of temperature from 0 to 40deg. C. makes a difference of less than 1 per cent. in the value. Also that boxes made some years ago are practically the same now.

The use of the instrument was shown in one of the checks used. This was to find the comparative resistances of the various boxes by direct deflections varying nothing but these with the megohms. With a very portable and accurate d'Arsonval galvanometer, the other boxes were checked rapidly; this was in effect measuring them, taking it for granted any one was right.

In measurements on the street, or in other places where it is difficult to set up and use an ordinary reflecting galvanometer, resistance-boxes, different batteries, etc., all that would be necessary to get a very close measurement would be such a galvanometer, suitable battery, and such a megohm resistance.

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* Paper read at the meeting of the Electrical Section of the Franklin Institute.

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DECORATIVE ELECTRICITY.

American notions are ubiquitous. Innovation in the New World is followed by innovation in the Old, hence the characteristic accompaniment of books is changing. The Murrays, Macmillans, and Longmans are still conservative enough to keep trade advertisements out of high-class books, and restrict the advertisement pages to literary announcements. No one thanks them for it, and they lose so many pounds. We must, however, on the other hand decline to consider productions containing trade advertising matter from a literary standpoint. If we mistake not, it was Aristotle in his Ethics who formulated the axiom "that each man judges well what he knows, and of these things he is a good judge," and we presume what is true of man is true of woman also. Thus Mrs. J. E. H. Gordon, in her book entitled "Decorative Electricity" (Sampson Low and Co.), writes of what she knows. In reading through this book, which touches upon the distribution of incandescent lamps in the various parts of a house, and the fittings appropriate to such lamps in such positions, we came across numerous sentences which might well serve as texts for homilies. It seems to us that Mrs. Gordon's book is calculated to greatly benefit the industry, and especially so if such sentences as those we have referred to could be emphasised in the minds of readers. It may be assumed that the readers of such a work are twofold—those engaged in the industry criticised, and those intending to install the electric light in their houses. The latter class is more or less at the mercy of chance words, and it is just this class, which should know what it wants, that is too frequently imposed upon by charlatans. In many cases enquiries are made at the offices of the technical papers; and it could easily be proved that many of the successful firms owe a considerable part of their reputation to the private information thus given, while again and again an emphatic "don't" has put an end to the efforts of the plumber-electrician. Any help that tends to warn against bad workmanship is welcome, and this is what Mrs. Gordon gives. What a sermon could be preached from the text, "It is more satisfactory to have the installation put in by one of the first-rate firms who thoroughly understand their business, than to be in haste and put in cheaper and inferior work; as, without care in the instalment, electricity is apt to be a fickle illuminant." The author tells us how the young electrician comes with his notebook to take orders, agrees that he knows the practical part of his business, "but of the requirements of a gentleman's house, and the best arrangement of lights in a lady's boudoir, he knows nothing." Here is another text: "The fire insurance rules do not permit the supply companies to turn on any electric current to the house until the whole installation work in the house is completed." Why not? How pregnant a moral could be drawn from this: "A 'plumber-electrician's' estimate is never inclusive, as he, like the jerry builder, lives entirely on his extras. . . The plumber-electrician will also send in a large account for alterations made during the progress of the work, alterations which as often as not he jesuitically suggests himself to the bewildered master of the house." In some instances we should add sentences to the statements made. Thus, p. 11, speaking of the convenience of switches, we should suggest that the "off" position should always be the natural position, and the "on" position that which the switch handle does not naturally fall into. Again, p. 26, with regard to linemen and central station switches, Mrs. Gordon says: "The practice at all properly-managed English central stations is to have brass tallies hung upon the switchboard under the switches controlling each circuit. On a lineman being sent out to repair any particular cable, the switch corresponding to it is switched off, and the lineman takes the tally with him, and the switch is on no account allowed to be put on again until the man has returned and replaced the tally." If this is the best practice in England it is superfinely bad. The switch should be so made after the fashion of locking gear, that till the tally was brought back it would be impossible to switch on. There should be no question of rules or regulations. The tally should form an integral part of the switch, which, when absent, breaks the circuit, and prevents the circuit being made till it is present. Of course there could be a "master tally," to be used only under extreme circumstances by the engineer-in-chief, and only when it was ascertained that the lineman was safe; in fact, in such a case as when the ordinary tally was accidently lost or destroyed. With what Mrs. Gordon says about decoration and fittings generally, we mostly agree, though tastes will differ as to the beauty of some of the designs patronised by the author. They are "too heavy and clumsy for the light lamps they support, the lines and curves are ungraceful"; while others, on the contrary, seem admirably adapted for the purposes for which they are designed. There is one text much too good to be left unquoted. It shows how necessary it is to watch over the action of servants. On page 135 is a description of what occurred at a large installation, in which the major part of the load ought to have been taken off the engines at six o'clock, when the clerks left. Investigation showed "that three charwomen were in the habit of turning on 1,500 lights to clean out the offices by." History says that all the lights were switched off while the charwomen were somewhere on the top floor, but history does not relate what became of the charwomen. We trust that many readers will take to heart the lessons Mrs. Gordon inculcates in this book. Finally, we may add that as we leave the decoration of our houses in a great measure, and rightly so, to our women-folk, it would seem that no one was better fitted, on the whole, to co-operate with mankind in advising as to electric fittings. It seems to us that here is another opening for the women of to-day to exercise their artistic faculties.

METROPOLITAN TELEPHONE SUBSCRIBERS.

On Wednesday a number of the London telephone subscribers met to make public their dissatisfaction with the telephone service and the charges of the telephone company. It takes years to obtain concerted action of this kind, but at length the mutterings which have been more or less heard have taken concrete form, and no doubt the telephone company will now make some attempt to stem the storm of antagonism and derision which has come to a head at the worst possible moment for the company. From first to last the company has played a high-handed game. Its board has never been in touch with those whose interest it is to see the work rapidly develop. We have never hesitated to say, so slovenly was the service, so exorbitant the charges, and so bad the system that the whole was a disgrace to London. When Londoners see what has been done by Mr. Lewis, of Bristol, by Mr. Bennett, now at Manchester, by Mr. Heaviside for the Government, at Newcastle, and in other places, there is no wonder that dissatisfaction should at length come to a head. From the speeches at the meeting it will be seen that communications have been made to the Post Office authorities, and that the authorities are by no means indisposed to supply a general demand. Hitherto the telephone company has been deaf to all remonstrance, and has carried on its business in a manner calculated to drive away its customers, and to lose the sympathy of the public.

ABERDEEN.

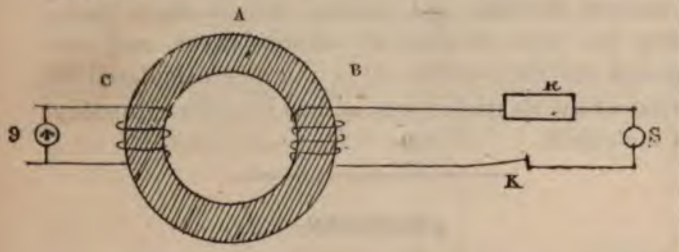
The Town Council of Aberdeen find themselves in the dilemma which it was expected certain corporations might experience. A provisional order has been obtained, and the consideration of the best means of putting it into force devolves on the Gas Sub-Committee of the Aberdeen Town Council. As a first step, a canvass of the town people was proposed and carried out, with, it soon appeared, apparently little support at this stage of the proceedings. Out of 149 tradesmen applied to, consuming £3,500 worth of gas per annum, only seven, representing £139 per annum, definitely promised to take the light, while 119, representing £2,530, refused at present to accept, while the remainder made no reply. Under these conditions there was no alternative left to the Corporation but to take advantage of the terms allowed by the Board of Trade, and delegate their rights to a company who will adopt a fighting attitude and convince the canny Scots of Aberdeen of the real and true worth of the light by actual experience. The Town Council, therefore, as will be seen in another column, advertise for tenders for undertaking the supply, for a period of not exceeding 21 years. The contractors are required to state the term for which they tender, and the rent or other consideration given for the powers acquired; to specify the system to be used and the security to be deposited; and, finally, the terms under which the Corporation, at the expiry of the period, may have the option of taking over the installation. The rent for such up-hill work as seems to be promised should not, it would seem, need to be very high.

CORRESPONDENCE.

LOOPS, LINES, OR CHAINS OF FORCE.

SIR,—Your argument, p. 344, appears to fully justify your preference for the use of the term "loops of force," rather than lines. The experimental facts are also simple, and soundly stated. But I submit that the whole notion of lines and loops of force is incomplete, and devoid of any intelligible relation to the physical facts. They need completion by some definite relation to natural facts.

In your illustration mechanical work is done in the galvanometer, G, by energy derived from the source, S; there is electric current in S which does not go to G; there is electric current in G which does not come from S. Where does it come from? How does the idea of "lines of force" explain it? Substitute for the lines or loops the idea of closed chains of polar or polarised atoms; recognise that electricity and magnetism are dual functions of the atoms, at right angles to each other, and that the effect of polar chains of either order is to divert part of the energy of the chain externally upon surrounding matter in the proportion of the inductance and magnetance of such matter, and the lines of force become living realities.



Follow this out in your figure. S generates a current, and sends energy proportional to its E.M.F. into the circuit, B. This surrounds the iron, A, at right angles, and the iron takes up energy from B, the current in which cannot rise to its full value till A is completely magnetised to the limit of the current power, because the energy which would be absorbed in overcoming resistance and producing current is being drawn off to magnetise A. This magnetism depends also on the number of turns of B, simply because each turn acts upon the same polar chains in A, just as a number of cells in series will add their E.M.F. to their circuit. Each turn is, in fact, a magnetomotive force in series.

But A is surrounded by the polarisable electric chains of the conductor C, and as its own magnetism grows it generates stress and current in C—a momentary current because the phenomena of magnetism, of which this is a function, are "static." There is no magnetic current, but only a stress. The momentary current in C produces, in turn, its own magnetic field, which tends to place the needle of G at right angles to itself.

In all this energy is being absorbed from S, and this process, acting as a counter E.M.F., gradually vanishing as the claims are satisfied, lowers the current generated by S until the whole field of force of A is developed.

When the circuit, B, is broken, the stress ceases, the ordinary conditions—that is, the internal forces of A—break up the chains, and the energy is freed in the polar chains to which it is connected. Part is lost in the internal frictions of A, hysteresis; part goes into C as an electric current, because of the two circuits in which current can form, C is closed, while B is broken. Again, the E.M.F. is cumulative in the turns of C, because each turn takes up its share of the energy from A, and the whole being one polar chain, the turns act as cells in series.

There is no hypothesis in this beyond the assumption, warranted by all the facts in our possession, that the ultimate particles of matter are polar bodies. I do not say anything as to the cause of this, but simply accept the fact and work out its results; all the rest is merely the looking at the known absolute facts of current and magnetism in the light of the polar forces of matter.—Yours, etc.
JOHN T. SPRAGUE.

OVERHEAD v. UNDERGROUND CONDUCTORS.

SIR,—I read with considerable interest the discussion going on in the London electrical journals relative to the cost of overhead as against underground electrical conductors.

Five years since the Chicago Telephone Company laid three 3in. diameter pipes from their exchange in La Salle-street to the corner of Jackson and Dearborn streets, about 3,500ft. There the pipes diverged. Each of the pipes had 510 No. 16 American gauge conductors—one of the pipes extended to Twenty-second-street—the entire length of this pipe was about three miles. The conductors were insulated with rosin oil. The three pipes were laid in a wooden trough about 1ft. wide and 4in. deep, and the space not occupied by the pipes was filled with pitch. You will see that 1,530 conductors, box and all, occupy a space less than 72 square inches, and that number of conductors by any means by which they can be strung overhead, make a very large and unsightly showing.

In New York, along West-street, between Courtland and Hoboken ferries, the north river side, there is a set of poles with 23 cross-arms, each cross-arm carrying 10 conductors, 230 in all. Now those 230 overhead conductors cost proportionately twice as much as the 1,530 underground conductors in Chicago. The poles mentioned are pine, at least 80ft. in height. Here comes the question of durability and reliability; how long will those poles and wires last, and how liable are they to interruption as compared to the wires underground in Chicago? The conductors and the inside of the pipe are preserved by the oil, the outside of the pipe preserved by the pitch. Is there any reason that those conductors in the ground should not last 60 years without interruption? We know the overhead structure will not last 10, and is liable to many interruptions.

It has been the custom in this country to bring the wires into the exchanges on the top of the building by way of a cupola or bird cage, as they are sometimes called. Almost every structure of that nature has been burnt out, switchboard and all, involving great expense and interruption to the service. The proper way is to bring the conductors into the building underground into the cellar, and 10,000 telephone conductors can be so introduced at comparatively little cost, avoiding all danger of destruction by fire.

As the distance increases from the exchange the number of conductors required decrease; a few carried inside of each block through a cellar and diverge in such manner as not to be seen from the street.

Where as many as 25 conductors can be brought into one channel between cities, it is cheaper to lay those conductors along country roads underground than to place them on poles, and I note with commendation the articles published by W. Slingo and Brooker touching that matter.

Yours, etc.,
G. H. B.

Chicago, April 3rd, 1891.

"AN ELECTRICAL ELYSIUM."

SIR,—With reference to the article in your valuable paper of the 10th inst. on "An Electrical Elysium," it seems to me that had Mr. Johnson been fully aware of the virtues of electricity as a curative agent in all diseases—acute or chronic—he would have added another "call" to the four mentioned by him—viz., "communication, light, power, and heat."

A medical electrician in Eastbourne-terrace, Paddington, who has made the subject his study and practice for nearly half a century, some years ago invented and patented an electromagnetic machine which a very able writer (Mr. Helsby, who had been a patient of the electrician referred to) states to be "the most perfect machine and mode of treatment in the world."

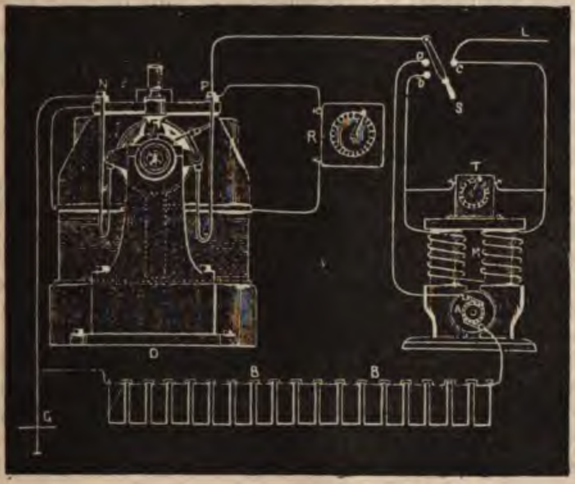
The machine is simple in its construction, and sends a beautiful current through the system *without any shock*, indicates at once the seat of any obscure ailment or disease, improves the circulation, prevents indigestion, and wards off colds. By its use the most difficult cases have been entirely cured, and it is a wonder that sufferers do not resort to its use, as in most cases it is the means of effecting a speedy cure.—Yours, etc., DAVID RODAN.

13, Upper Montague-street, W., April 15, 1891.

EQUALISATION OF LOAD AT CENTRAL STATIONS.

The development which has taken place in the use of accumulators has enabled us to equalise within certain limits the load upon the engines at central electric lighting stations, which otherwise would be subject to considerable and frequent variations dependent upon the number of lamps in circuit. In certain central stations for the transmission of power, particularly in those for electric railways, the variability is very much greater than in electric light stations. The variations of traffic, and the loss along the line, continually modifies the load upon the engines, which often pass without transition from minimum to maximum. Cannot this state of things be modified favourably, and the loads on the engine be rendered uniform within certain small limits? Such is the question which M. O. Mailloux has attempted to solve by an arrangement of subsidiary dynamos and accumulators, and *L'Electricien* gives the following abstract of the inventor's description.

M. Mailloux first of all points out that a very considerable part of the energy of the steam engines in a generating station of an electric railway remains unemployed during the greatest part of the whole time. From a motor of 100 h.p., for example, not more than 40 h.p. or 50 h.p. is usually required, and it is only at rare intervals when the engine is required to be worked up to the full power for which it has been built. It is clear that these are not conditions of economical working. M. Mailloux proposes to remedy this disadvantage in the following manner.



In the accompanying figure, D represents the dynamo at the generating station, whose negative pole, N, is connected to earth by the rails at G. The positive conductor, P, is connected to a switch contact, S, which, pulled to the right against the contact, *c*, puts the dynamo, as usual, into direct communication with the line wire, L, of the track. When, however, the switch is pulled over to the left against the contacts *a* and *b*, the current passes from the dynamo, D, on the one part by the field magnet, M, on the other part by the armature, A, of an auxiliary machine, and feeds the battery of accumulators, B B, whose other pole is in communication with the earth terminal of the principal dynamo, D. The two dynamos are furnished with shunt resistances, R and T.

The auxiliary dynamo is driven by the same engine as the principal dynamo, or, if preferred, can be driven by an electromotor. This machine supplies the current to the line exactly in proportion to the demand. If, for instance, at a certain moment the line requires little or no current, and if the switch lever is upon the contacts *a* and *b*, there will be little or no current passing by way of the field magnet, M; consequently the current will flow by the armature, A, of the auxiliary dynamo, which immediately ceases to act as passive resistance, and commences to charge the battery, B. When, on the other hand, the field magnet is excited by a sufficient current, the armature, A, furnishes a corresponding pressure, which is added to that of the principal dynamo. Lastly, when the line suddenly demands an abnormal current—which never lasts very long—the battery of accumulators comes in aid of the dynamo.

The winding of the armature, A, ought to be such as will meet the maximum requirements; the plates of the battery, B, should be such that they will stand the passage of a fairly large current, either in charge or discharge.

To illustrate by an example the conditions of working of the proposed arrangement, let us suppose the line to be supplied by a dynamo of 50,000 watts at 500 volts pressure. This dynamo, which requires an engine of about 100 h.p., would only have to develop for the greater part of the time about 60 amperes instead of 100. If it is driven by an engine of 80 h.p. and an average of 90 amperes were given, the battery should be arranged to supply the rest of the current. There might be cases in which it was necessary to develop 180 amperes. In these cases, when the current must exceed 90 amperes as an average, the principal dynamo should supply about 45,090 watts, with a pressure of 501 volts at the terminals. The accumulators arranged to give a discharge at 1·8 volts per cell, would give 405 volts with 225 cells; the auxiliary dynamo would thus be required to furnish 501 – 405 = 96 volts.

The auxiliary dynamo would, therefore, have to develop 96 volts and 90 amperes = 8,640 watts, and the accumulator 45,090 – 8,640 = 36,450 watts; and it is to furnish this work, then, (405 volts × 90 amperes) that the battery should be constructed. A sudden demand of 180 amperes—that is, of 100 per cent. over the average—will only increase that of the dynamo by 20 per cent., the other 80 per cent. being furnished by the accumulators.

We might also take the conditions by which the principal dynamo should give a maximum of 80 amperes, and 100 amperes should be supplied by the auxiliary installation. Then the dynamo would have to supply 80 amperes × 500 volts = 40,000 watts, and the auxiliary dynamo, 100 amperes × 96 volts = 9,600 watts; total 49,600 watts—that is, 4,600 watts, or 10 per cent. more than the mean (45,090 watts) allowed for in the principal dynamo. The accumulators would have to develop, on these occasions of greatest demand, 100 amperes × 405 volts—that is, 90 per cent. of the average.

ELECTROLYSIS OF SILVER SALTS.

BY ALEXANDER WATT.

(*Concluded from page* 161).

25. *Ammonio-Carbonate of Silver.*—A solution of this salt was prepared by dissolving moist carbonate of silver in a strong solution of carbonate of ammonia, the liquid being afterwards diluted with about three volumes of water. Electrolysed with the current from one Daniell cell, a deposit of silver upon a clean brass plate was readily obtained, but the colour of the film, however, soon assumed a somewhat dark tone, therefore it was deemed advisable to still further dilute the solution, when the deposit slightly improved at first, but eventually acquired the same dark tone as before. Fresh additions of water were made from time to time with a view to obtain a better coloured deposit, but when the solution had attained a very weak condition in this way the subsequent deposits acquired a blue colour on portions of the plate, and eventually the coating turned a dark brown colour. A plate of steel immersed in the solution when in its weakest condition readily received a coating of silver, which adhered pretty well at first, but after a longer

immersion the deposit turned a blue colour, and was easily rubbed off the plate with the finger.

26. *Silver Carbonate in Sulphate of Ammonia.*—A quantity of moist carbonate of silver was digested in a strong solution of sulphate of ammonia. The resulting solution, after filtration, was electrolysed with the current from one cell, when a white film of silver at once formed on a freshly-prepared brass plate, but this soon became iridescent, and finally of a blue colour. The solution was weakened from time to time by fresh additions of water, and a plate of steel was immersed after each dilution of the liquid—the object being to get an adherent coating of silver direct on that metal if possible—but though the silver adhered with tolerable firmness on parts of the plate, the scratch-brush stripped the metal from other portions of it. At one time it really appeared as if the silver would condescend to "stay on" the steel surface, especially when the cathode was kept in motion while in the solution; by the time a film of moderate thickness had been deposited, however, the fatal stripping or peeling off of the metal once more asserted itself, when the trial was reluctantly abandoned so far as this solution was concerned.

27. *Silver Carbonate in Ammonia Acetate.*—Moist carbonate of silver, as before, was digested in a strong solution of acetate of ammonia, and the liquor, after being filtered, was tried with the current from a single cell, when a white deposit of silver slowly formed on a brass plate, to which it adhered pretty firmly. A plate of steel was next immersed in the bath, when a prompt film of silver was obtained; but this did not adhere to the steel surface. The solution was now diluted, and a fresh steel plate immersed; but no improvement occurred in the adherence of the silver. Further dilutions of the solution were subsequently tried, but though the metal was somewhat more adherent when deposited from the weaker baths, a perfectly sound coating could not be obtained.

28. *Silver Carbonate in Ammonia Nitrate.*—A solution was prepared by dissolving moist carbonate of silver in a strong solution of nitrate of ammonia, the liquid being afterwards diluted with about two volumes of water. With the current from one cell, the deposits obtained from this solution were almost identical with those above described. The solution required to be considerably diluted before even a tolerably adherent film of metal could be obtained upon brass, while to steel the metal absolutely refused to adhere.

29. *Silver Carbonate in Tartrate of Ammonia.*—A bath was prepared, as before, by digesting the moist carbonate in a strong solution of tartrate of ammonia, the liquid, after filtration, being diluted with two volumes of water. With the current from one cell, a very quick deposit of a good white colour was at first received upon a brass plate, but the film assumed a dark colour after a short immersion. The liquid was still further diluted from time to time, but these modifications failed to secure a perfectly adherent coating, either on brass or steel. Respecting the non-adherence of the silver upon the brass plates used in these trials, it must be borne in mind that the naked metal was used in each case—that is to say, there was no intermediate film of mercury employed, as in the ordinary operation of electroplating. It is more than probable, therefore, that brass, copper, and German silver, previously coated with a film of mercury in a nitrate or other solution of the metal, in the usual way, could be firmly coated with silver in many of the solutions described.

30. *Potassio-Tartrate of Silver.*—A bath was prepared by digesting moist carbonate of silver in a strong warm solution of cream of tartar. The solution, when cold, was filtered and diluted with about two volumes of water. With the current from one cell a golden-yellow non-adherent film was obtained, beneath which was a thin film of white metal which adhered to the plate. The solution was repeatedly diluted with water, but the subsequent deposits were, as before, non-adherent. The yellow deposit, which readily rubbed off the surface of the plate with the finger, was doubtless metallic silver in a fine state of division, and would, after a prolonged immersion of the plate, take the form of spongy metal.

31. *Silver Bichromate in Ammonia.*—A solution of this constitution was formed by precipitating a solution of nitrate of silver with one of bichromate of potassa, and the precipitate, after being well washed, was dissolved in strong liquid ammonia. The solution was next diluted with three volumes of water and electrolysed with the current from a single cell, when an iridescent film appeared on a freshly prepared brass plate, which soon assumed the bright blue colour of "blued" steel, the deposit adhering only partially to the brass surface. It is a curious fact that solutions containing even a slight excess of ammonia have generally a tendency to deposit silver of a more or less blue colour.

32. *Silver Carbonate in Bisulphate of Potassa.*—Moist carbonate of silver was digested in a strong solution of bisulphate of potash, and the resulting liquid, after filtration, was diluted with about two parts of water. With the current from one cell, a spongy deposit of silver quickly formed at the corners of the plate, so the liquid was further diluted with water, when the next deposit obtained appeared of an orange-yellow colour; even when the solution was rendered exceedingly weak by copious additions of water the metal still deposited in a non-reguline state, with the exception of a slight white film of the metal which adhered to the plate.

33. *Silver Pyrophosphate in Ammonia.*—A quantity of pyrophosphate of silver was digested in liquid ammonia, in which it became freely dissolved, and the solution was then diluted and filtered. With the current from one cell, a fairly adherent deposit of a somewhat darkish colour formed on a brass plate soon after immersion. A plate of steel was next placed in the bath, which quickly became coated with silver, and after a short immersion the plate was submitted to the action of the scratch-brush, which treatment it well withstood without stripping. It is not improbable that a carefully prepared solution of this composition might be worth trying again as a bath for coating steel with silver; the solution, however, must be rather weak, and as little excess of ammonia as possible in the liquid. If a solution of this kind could be used for silvering small articles without previously coating them with copper or brass, it might be found useful.

34. *Phosphate of Silver by Electrolysis.*—A moderately strong solution of phosphoric acid was first prepared, in which was placed a silver anode and plate of clean brass as the cathode, the electrodes being connected to two small Daniell cells arranged in series. In about 10 minutes after the plates were immersed, a nearly black deposit of spongy silver appeared at the lower corners of the brass plate, and in the course of half an hour or so the deposit, which had spread to the extent of about three-fourths of an inch in the direction of the anode, at the bottom of the vessel, acquired a graduated tone of colour, from black to dark grey, and becoming of a lighter grey colour at the parts furthest from the cathode. Having observed, when depositing lead, tin, etc., from their solutions, that after a certain quantity of the metal had deposited in the spongy form, crystals of a more or less branching or fern-like character eventually grew out from the outer edge of the spongy mass nearest the anode. I determined to ascertain if such would be the case in the present instance. I was encouraged in the belief that the metal would ultimately arrange itself in the crystalline form referred to by the fact that the deposit, from its starting point at the cathode, where it was perfectly black, gradually became lighter in colour as the surface of the deposited spongy metal became greater, and it also became evident, after a time, that the edges of the deposit, the mass of which had extended to about 2½in. in width by about 2in. in length, were gradually assuming a somewhat feathery appearance. The arrangement, under these conditions, was allowed to remain undisturbed for about an hour longer, when it was found that the metal had, in fact, formed itself into branching crystals of great beauty, but so exceedingly delicate and fragile that the slightest movement of the liquid disarranged them. In a short time after—for the growth of crystals under these conditions always increases with great rapidity as the deposit approaches the anode—it was found that the crystalline metal had reached the anode, when, of course, the current stopped. The solution of phosphoric acid having

now become a fairly strong solution of phosphate of silver, it was transferred to another vessel—leaving the spongy and crystalline metal in the first vessel—and the liquid was next electrolysed with the current from a single cell. A brass plate being immersed, a white film of silver at once formed on the plate, but, as before, the metal assumed the spongy character at the corner of the plate; instead of being black, however, as was the case when two cells were employed, the deposit was of a dark grey colour, graduating to lighter tones of grey, until a deposit of about an inch in width had been formed, when the edges nearest the anode appeared of a pure white colour. When the anode was momentarily lifted out of the solution, the darker shades of the deposit instantly turned to a pure white, and continued so during the remainder of the experiment. With the weaker current (one cell) the deposition of the metal—which had assumed throughout a sparkling, crystalline aspect, except at the surface in contact with the cathode—was very rapid, and as the mass extended in the direction of the anode the disposition of the metal to assume the tree-like form of crystallisation became strongly apparent. It was not, however, until the deposit had spread to within 1½in. or so of the anode that the actual growth of branching crystals commenced, the period being when, as before observed, the rapidity of the deposit (as seen by its elongation in the direction of the anode) was greatly on the increase, at which point tree-like crystals spread out with great vigour. The anode was now slowly and carefully removed farther away, when the branching form of crystallisation continued, and would doubtless do so without limit on a surface of sufficient capacity.

35. *Crystals of Silver from the Sulphate by Electrolysis.*—A 1 per cent. solution of sulphuric acid was first prepared, in which was placed a silver anode and brass cathode, as in experiment 14, but the object in view in the present instance was to see if the metal would assume the crystalline form, and of what character, from the sulphate prepared in this way. For this purpose the current from one cell only was taken, when in the course of a few minutes after the immersion of the electrodes, spongy silver commenced to deposit, as usual, at the corners of the plate. The arrangement was now left undisturbed for about half an hour, at the end of which period it was found that a considerable mass of white, sparkling, crystalline metal had formed, and was spreading out in the direction of the anode with considerable rapidity. The positive plate was cautiously moved farther from the deposited metal from time to time, care being taken not to disturb the delicate crystalline fabric, and by the time the electrodes had been separated to the extent of 4in. or 5in.—their original distance apart being 1in.—branching crystals of great beauty and of extreme tenuity had grown out of the more spongy but brilliant mass, presenting a remarkably pleasing effect.

ELECTRICAL TRANSMIGRATION.

When Mr. F. L. Pope was visiting the electroplating works at Ansonia, he saw a careless workman unthinkingly place a metal pail on the two omnibus conductors supplying current to the baths. The pail instantly disappeared, not only being fused but converted into metallic vapour, illuminating the whole shop with a flash of startling brilliancy, and this though the low-pressure current, of course, could not be even felt by the hand.

SOME RECENT IMPROVEMENTS IN LEAD SECONDARY BATTERIES.*

BY J. T. NIBLETT, MEMBER.

(*Continued from page 374.*)

In one form of cell three of these elements are mounted. They are held firmly in their relative positions by means of vulcanite distance pieces wedged vertically between them. From the arrangement of the plates, all buckling or warping merely tends to bend them vertically and not horizontally; therefore short-circuiting of the elements is very improbable. Although the internal resistance of this form of cell is somewhat higher than in those where the active surfaces are nearer or more directly exposed, yet they have a very large active surface; and as the space between each little plate is so small, detached scales of oxide, other than those of small dimensions, cannot leave the troughs; therefore they do no damage, but merely become inactive. In cases where batteries are liable to receive much jolting or concussion, this form of cell seems likely to be of great service.

Bristöl's Portable Battery.—Bristöl constructs elements suitable for small portable storage batteries by incorporating oxides of lead with some binding material, such as asbestos fibre, animal hair, horn shavings, or some similar fibrous substance capable of giving the mass sufficient cohesiveness to retain its shape without the aid of a metallic support. The oxides when mixed with from 1 to 3 per cent. by weight, of the fibrous material, are found to have sufficient mechanical strength to resist all ordinary disintegrating influences, either mechanical or electrical. When the binding material is mixed with the metallic oxides, the mass is made into a stiff paste, and is pressed into moulds to give it the desired shape. As a conductor, either a flattened lead wire or a platinum strip with lateral branches is inserted within the soft mass.

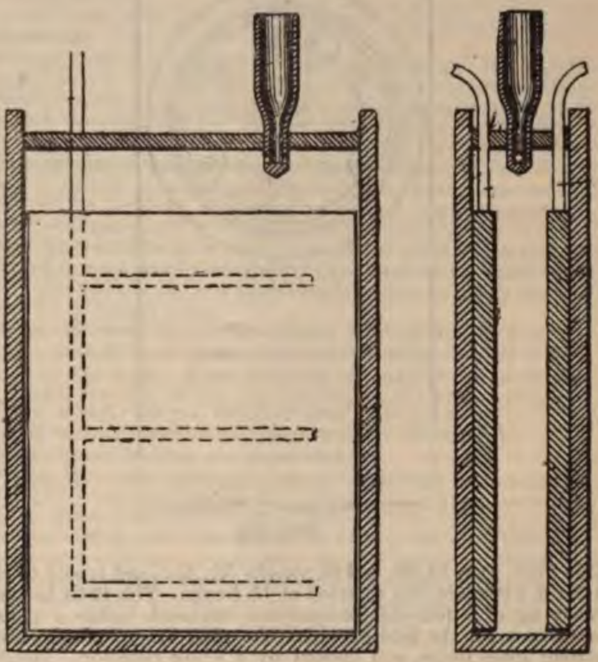


FIG. 20.

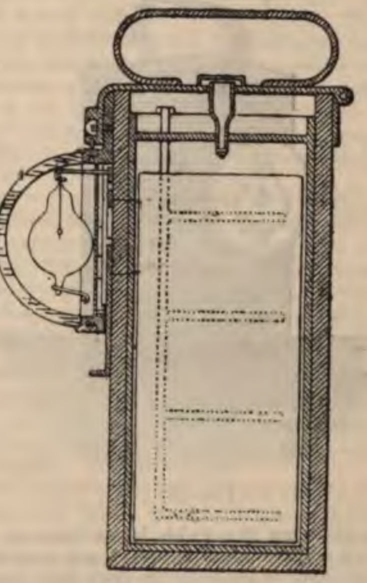


FIG. 21.

When dry the masses are "formed" in an acid bath by the usual method. When making up cells suitable for hand lamps, only one positive and one negative element is used. Distance pieces of wood saturated with paraffin wax, or some similar insulating substance, are placed between the elements to keep them at the proper distance apart. In order to prevent the liquid splashing or leaking out, each receptacle is sealed by a vulcanite cover, having a small vent hole, and a hollow ebonite plug fitting into it. The vertical orifice in the plug does not go quite through, but terminates in a small opening running transversely. During the charging the vent plug may be removed, but when it is fixed the cells are practically sealed, and may be held in any position without the electrolyte escaping, Fig. 20.

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* Paper read before the Physical Society of the Glasgow University, 13th January, 1891.

The Bristöl form of element is found to be peculiarly suited to the requirements of an electric hand lamp. Several very neat, light, and compact safety miners' lamps of this type are now made.

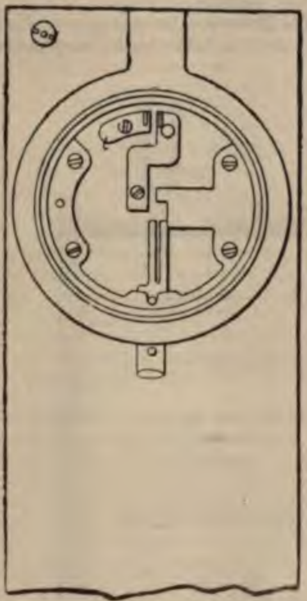

Fig. 22.

One form, Figs. 21, 22, and 23, weighs 5lb. 4oz., and is said to run a 1·5-c.p. glow lamp for a period of 15 hours. This little battery is made up of a four-cell accumulator enclosed within a polished wood case, on the face of which the glow lamp is fixed within a strong glass dome, and backed by a white reflector. The wood containing case has a hinged metal lid with a projecting lug which covers one of the charging terminals; so that when the lid is closed the battery cannot be short-circuited. The metal cover also carries a simple form of lock, by which it can be secured; a small pin in this lock fixes the glass dome, and prevents it being removed. The glow lamp is held in position by two flexible terminals and a top spring. The elastic hook terminals are attached, the one to the positive pole of the battery and the other to an independent plate, between which and the negative terminal of the cells circuit is either made or broken, by a small spring sliding switch passing through a groove underneath the glass dome vessel.

By trial I found that a three-cell hand lamp of this type, weighing with its lantern just 4lb., maintained fully incandesced a 5·5-volt lamp, taking 0·35 of an ampere, for a period of fully 10 hours.

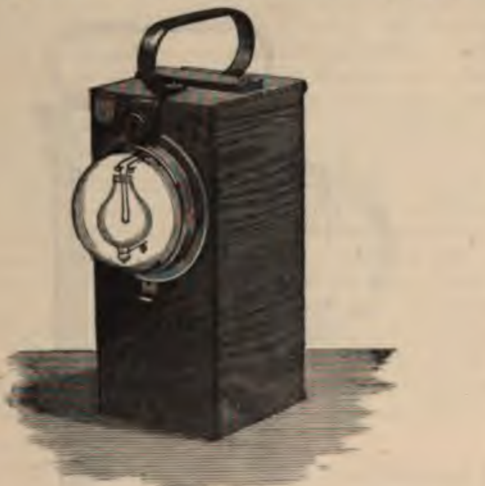

Fig. 23.

Mr. Bristöl now tells me that in his latest form of cell he can obtain from 4½ to 5 ampere-hours capacity per pound of battery complete, and that some of his batteries have been known to hold their current on open circuit for a period of eight months. As regards the durability, I am assured that Bristöl batteries made three years ago, which have been almost in constant use, are now in perfect condition.

Lithanode.—Probably no one in this country has given more thought and attention to the subject of storage batteries than Mr. Desmond FitzGerald. His paper, read before the British Association in September 1886, on "Lithanode," and another delivered before the Institution of Electrical Engineers on March 10th, 1886, entitled "Reversible Lead Batteries," together with many communications to the technical journals, have done much to throw light upon the vexed question of the chemical action due to electrolysis in lead storage cells. As an example of an active element for an accumulator, without a metallic or mechanical support of any kind, lithanode certainly stands alone.

In his early experiments, FitzGerald found that by incorporating oxides of lead with mixtures of pure glycerine, diluted with about twice its volume, either of water or a half-saturated solution of sulphate of ammonia, or with a solution of sulphuric or phosphoric acid, he obtained the best results. The advantages of these solutions over all others he had tried, is to be attributed to the fact that with aqueous mixtures the resulting compound of lead is hydrated, whereas when glycerine combined with sulphate of ammonia or acid solution is used, the resulting compound is necessarily anhydrous.

In the commercial manufacture of "lithanode," the oxide of lead is made into a paste by moistening it with one of the solutions referred to. The soft mass is pasted in a die-plate of the form of the element required; it is then subjected to great pressure in a hydraulic press. When dry and hard, the plates are superficially converted into peroxide by treating them with hypochlorite of magnesium, or other suitable chlorine compound. The preliminary coating ensures uniform peroxidising when the elements are finished off by electrolysis in the acid bath.

The amount of peroxide in the lithanode plate can be regulated by suitably proportioning the materials used, or by the depth of "formation." A small amount of sulphate seems necessary to give it the requisite cohesiveness and mechanical strength. The more recent form of plate is said to contain fully 90 per cent. of peroxide. When used as an element in a cell, the pole is formed by a thin sheet of platinum, which is tightly clamped to the slab by vulcanite plates and screws. The platinum, being pressed directly upon the active material, ensures good electrical contact, and is quite unaffected by the corrosive solution or electrolytic action. Lithanode is only useful as a positive element; the negative may be of the ordinary grid form, filled in with spongy lead or litharge.

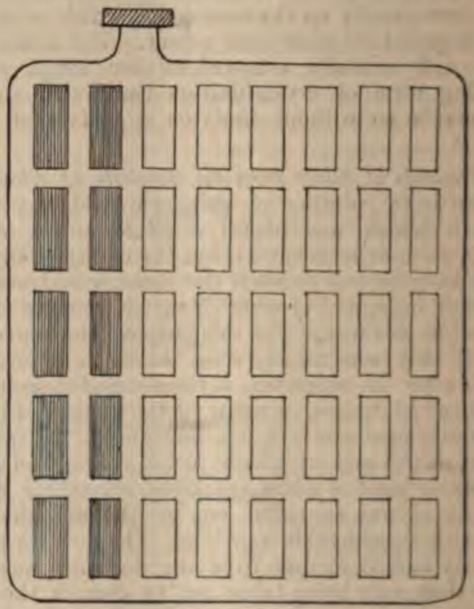

Fig. 24.

Recently, Mr. FitzGerald, in conjunction with Dr. Frankland and Mr. G. Hough, have still further developed these battery elements. Large plates are now made, and as they are much lighter than the ordinary grid form of plate, they are said to be eminently suited for traction purposes. The positive elements, Fig. 24, are made up of a number of small moulded slabs of lithanode, whose outer edges are V shaped. About 40 of these little slabs are placed in a suitable metallic frame or mould, and the interstices are filled in with molten lead. Owing to the shape of the pellets they cannot fall out, and as they have been thoroughly "formed," and therefore expanded to their fullest dimensions, they exert no pressure on the metal frame and do not tend to bend it. The negative element is constructed in a rather curious and original way. By experiment it was found that a sheet of copper, if covered with metallic or spongy lead, might be used as the negative plate in a secondary couple. The copper, which forms an excellent conductor, is not in any way affected by the acid solution nor by the electrolytic action.

Acting upon this experience, the present form of element, Fig. 25, was devised. It consists essentially of a double network of fine copper gauze, coated with lead by dipping it in the molten metal. Upon this frame the active material is compressed in a solid block, the copper affording a perfect support, and thus a spongy lead plate of much reduced weight is obtained. It is asserted that the same capacity can be obtained with 50 per cent. less weight. In a complete cell, the glass containing vessel, electrolyte, and peroxide plate being of the same weight as before, this improvement alone gives a gain of 15 to 20 per cent. on the total weight of the cell. Mr. FitzGerald is still endeavouring to reduce the weight of his elements. In a communication I lately received from him he says: "The capacity of the lithanode as now made, when worked at a moderate rate of discharge (continued until the E.M.F. at poles has fallen from 2 volts to 1·8) is one ampere-hour per oz. A plate 7in. by 4in., weighing 12oz., will maintain a discharge of three amperes for a period of 2½ hours without alteration in the external resistance; if the external resistance is slightly diminished from time to time, a rate of discharge of 4·4 amperes can be obtained during a period of two hours.

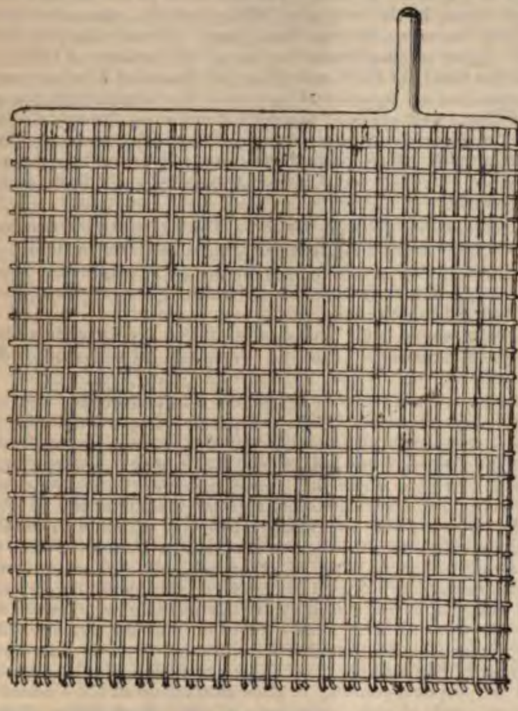

Fig. 25

FitzGerald's Electric Hand Lamp.—Of late years small electric hand lamps of the lithanode type have been used for mining and other purposes. Quite recently a rather novel form, Figs. 26 and 27, has been devised. The improved lamp consists of an inner two-cell battery in a vulcanite case, and an outer containing box made of thin sheet steel. Between the inner and outer cases a small air space is left. The battery cell is firmly held in position by means of indiarubber studs. These elastic studs prevent damage to the inner cells should the lamp be subject to accidental knocks. On the front of the metal case is fixed a 3·5-volt lamp protected by a stout glass dome. An arrangement is made for locking the lid and covering the charging terminal during the discharge, and a small switch serves to throw the lamp in and out of action.

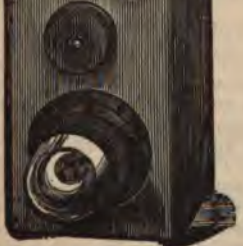

Fig. 26.

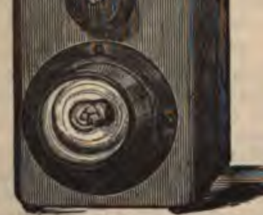

Fig. 27.

Separators.—A very large number of patents have been obtained for devices for keeping the plates in accumulator cells the requisite distance apart, and preventing them from warping or buckling. The most simple and efficient of the plans suggested seems to be the employment of vulcanite strips, ⅜in. or ½in. wide, bent into a **U** shape, and pushed down over the plates. Two or three of these distance-pieces between each pair of elements is considered sufficient when the cells are to be used for ordinary purposes.

(To be continued.)

A NOTE ON SOME DANGERS IN ELECTRIC LIGHTING.[*]

BY WM. MCDEVITT, INSPECTOR OF THE PHILADELPHIA BOARD FIRE UNDERWRITERS.

After several years of experience in noting the dangers occurring in the use of electric lighting, it has been clearly demonstrated that in nearly every case the accidents resulted through ignorance both on the part of the workmen engaged in installing the wires and the lessee to whose care the new apparatus was entrusted.

These practical illustrations served as valuable lessons to those who witnessed them, more especially to the workmen, whose education in the business consisted merely in following plans laid out by the contractor.

Although the introduction of electric lighting has rapidly increased in our city, its use has been comparatively free from accidents, proving that most of the inherent dangers have been controlled, leaving but few features that require the attention of inventive minds to overcome. The most important of the existing defects is that relating to fusible connections, as the innumerable variety of alloys used for fuse metal is very misleading, and is still an element of danger. Some of these compositions possess the properties of good electrical conductivity and are slow to heat; other compositions are of a character exhibiting weakness when heated, resulting in annoyance from continuous breaks and offering temptations (as has been found) to use ordinary wire in the absence of proper fuses.

Another universal danger in electric lighting results from the want of some uniform or more ready method of perfecting splices or joints in conductors. Some workmen are in the habit of making loose copper unions, leaving the solidity of the joint dependent on solder, which, being a metallic cement, is liable to be fused by a possible heavy short-circuit occurring on the line, thus melting the solder and leaving a loose connection.

Probably the most alarming danger exists through the possibility of lightning being conducted into houses lighted by electricity where the latter is supplied by aërial wires. The existence of this danger has been demonstrated where the house wires are attached to gas fixtures, offering a ready path for the lightning, which, in leaping from the charged wires to the gas-pipes, carries the electric light current across, forming an arc, which pierces the pipe, and where gas is present, it will be ignited, causing a steady blaze. If this accident should occur near the ceiling, the building would be endangered.

With the rapid introduction of new appliances in electrical science, it may reasonably be expected that the defects above mentioned will be overcome in the near future.

INSTALLATION AT DUNSTON FLOUR MILL.

The Co-operative Wholesale Society's flour mill at Dunston-on-Tyne has been lighted throughout by Messrs. Ernest Scott and Mountain, electrical and general engineers, The Close Works, Newcastle-on-Tyne.

This installation is the largest in a flour mill in the United Kingdom, and is very complete in its details. The total installation consists of about 600 16-c.p. incandescent lamps.

The generating plant consists of three vertical engines. Two of these engines are compound, and are each capable of working up to 60 i.h.p. or 70 i.h.p. The third engine has a single cylinder, and works up to 15 h.p. The two larger engines drive on to two of Messrs. Ernest Scott and Mountain's Tyne compound-wound self-regulating dynamos.

Each dynamo is constructed to run, when lightly loaded, 400 16-c.p. incandescent lamps, but is capable of working up to 600 incandescent lamps in case of emergency, so that under ordinary circumstances one dynamo and engine would be powerful enough to feed the whole of the incandescent lamps ordinarily used.

When the whole of the lights are required both engines and dynamos will be run lightly loaded, and in case of a breakdown occurring one engine and dynamo will then be able to carry the whole load.

The jetty and mill yard is lighted with 10 2,000-c.p. Tyne arc lamps, the current for these lamps being supplied by a compound-wound Tyne dynamo, the power being obtained from the small vertical engine.

The four arc lamps on the jetty are carried on poles 25ft. from the ground, and fitted with raising and lowering gear so that the lamps can be lowered for recarboning. The lamps for lighting the yard are suspended from the building by strong wrought-iron brackets also fitted with raising and lowering gear, and the lamps themselves are encased in water-tight lanterns with large iron reflectors, so that the whole of the light is thrown downwards.

The current from the incandescent dynamos is led to the main switchboard, and there passes through special coupling switches, so that the dynamos can be connected in parallel—*i.e.*, two dynamos can both feed on to the same set of mains. From the coupling switches the current passes through six double-pole main switches fitted with double-pole cut-outs, and is divided into six circuits feeding the lamps in the north mill, south mill, grain warehouse, flour warehouse, offices, stables, and engine-room.

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[*] Paper read at the stated meeting of the Electrical Section of the Franklin Institute.

By this method of dividing the circuits the different portions of the mill are independent of each other, and can be switched on or off by the dynamo attendant from the engine-room, and in the event of any accident occurring to any of the circuits this would not affect the general lighting of the mill.

The current from the arc light dynamo is also taken to a main switchboard, upon which 12 adjustable resistance coils are mounted, each coil being fitted with a switch and cut-out. The current then passes through the adjustable resistance coils to the 10 lamps through separate wires, and back to the dynamo by a negative cable common to the whole of the lamps.

This arrangement also enables any or all of the arc lamps to be switched on or off from the dynamo-room, and as only a portion of the installation will be required at any particular time a great economy in driving power will be effected, as the dynamo is so constructed that the power required to drive it is exactly in proportion to the number of lamps burning.

Both of the main switchboards are of a very handsome description, and consist of large enamelled slate bases carrying the switches, the slate base being mounted in a deep oak frame. All connections are at the back of the board, arranged so that the connections can be examined when required.

The fittings used throughout the installation are very substantial.

There is a china ceiling rose with fusible cut-out to each lamp. Lampholders are of the Edison-Swan type, to take bayonet socket lamps with brass cord-grips, and the shades are of enamelled iron, 10in. in diameter.

In some portions of the mill rising and falling pendants have been used, so that the machinery can be more carefully examined whilst at work, and at the end of each room bulkhead lamps have been fitted for general illumination.

A very complete system of electric bells has also been fitted by the same firm. There are in all 30 bells with 5in. gongs, and two bells with 9in. gongs. The small bells are placed in the different departments throughout the mill, the two large bells being placed in the engine-room.

When it is proposed to start the engine, the engine-driver presses a push, which rings the whole of the bells in the north mill, and a second push rings the bells in the south mill. The men in charge of the various departments then ring back to an indicator. When the engine-driver sees that all the drops have fallen, he knows everything is clear, and his engine can be started. In the event of an accident a man in any portion of the mill can ring one of the large gong bells, when the engine is at once stopped.

The installation throughout has been carried out in a most complete and satisfactory manner, and has given great satisfaction to the officials connected with the Co-operative Society and their engineer, Mr. John Thompson, under whose supervision the work has been carried out.

LONDON COUNTY COUNCIL AND ELECTRIC LIGHTING.

At the meeting of the County Council on Tuesday, the Highways Committee reported as follows:

On January 13 last we reported to the Council in general terms upon the new model form of provisional order issued by the Board of Trade, and the Council, upon our recommendation, gave instructions that the Board of Trade should be informed that the Council desired various amendments of detail so as to make particular orders correspond in substance with the principal orders granted last session, leaving these details to be settled when the orders were deposited.

We have now had under consideration a number of orders forwarded by the Board of Trade, of which the following is a list:

(*a*) Wandsworth District Electric Lighting Provisional Order.
(*b*) City of London Electric Lighting (Brush) Provisional Order.
(*c*) Islington ,, ,, ,, ,,
(*d*) Camberwell ,, ,, ,, ,,
(*e*) St. Luke's, Middlesex ,, ,, ,,
(*f*) Clerkenwell ,, ,, ,, ,,
(*g*) Westminster ,, ,, ,, ,,
(*h*) Woolwich ,, ,, ,, ,,
(*i*) Hackney ,, ,, ,, ,,
(*j*) Chelsea ,, ,, ,, ,,

The Board asked that any observations which the Council wished to offer should be sent in at the earliest possible moment. We have accordingly taken these orders into consideration, and under the authority of the resolution of the Council above referred to, have suggested to the Board of Trade that the following amendments should be made in them.

Wandsworth, Islington, Camberwell, St. Luke's, Middlesex, Clerkenwell, Woolwich, Hackney and Chelsea Orders.—That the duty of appointing auditors be left with the Board of Trade; that the regulation with reference to overhead wires, contained in clauses 10 and 83 of the Wandsworth order and corresponding clauses of the other orders, be recast so as to correspond with the form of clause in the orders of 1890; that the guarantee period for consumers be reduced from three years to two; that the definition of the duties of inspectors be, as in the orders of 1890, entirely left in the hands of the Council or the Board of Trade according as the inspectors are appointed by one or the other; that the supplying of maps and plans of the authorised areas be made obligatory on the undertakers; that the purchase clauses be made to run from the 26th of August, 1889, and not from the date of the passing of the Acts confirming the orders; verbal and minor amendments.

City of London (Brush) Order.—The suggested amendments in this case are confined to unimportant alterations of detail.

Westminster Order.—The only amendment, other than verbal, we had to suggest in this order was that the Council's bridges should be excluded from the area.

We recommend that the course taken by us with reference to the above-mentioned electric lighting provisional orders be approved.

Subways.—We have considered an application by the superintending engineer, Post Office Telegraphs Department, for permission to suspend an additional cable in the Victoria Embankment subway to the existing line of pipes between New Bridge-street and Charing Cross; to lay a line of 3in. pipes across the carriageway opposite the south end of Craven-street, and to take one end of the pipes into the subway, and to connect the end of an additional line of 3in. pipes with the subway at New Bridge-street. There appears to be no objection to what is proposed; and we recommend that the sanction of the Council be given to the execution, by the Post Office Telegraphs Department, of the works above specified, upon condition that all the works shall be carried out, and that any damage that may be done to the subways or to the carriageway of the Victoria Embankment in their execution shall be made good, under the supervision and to the satisfaction of the Council's chief engineer, and at the sole cost of the Post Office Telegraphs Department.

We have considered an application from the Exchange Telegraph Company for permission to lead a wire from the existing cable in the subway of Shaftesbury-avenue into the Lyric wine bar, No. 8 in that thoroughfare. We see no objection to what is proposed, and we recommend that the required permission be given to the Exchange Telegraph Company to make the connection referred to in the application, upon the condition that the work shall be carried out, and that any damage that may be done to the subway in the execution of the work shall be made good, under the supervision and to the satisfaction of the Council's chief engineer, and at the sole cost of the company.

Notices under Electric Lighting Orders and Acts.—We have considered notices from the Westminster Electric Supply Corporation as follows:

20th March, 1891 (registered No. 180), of intention to lay mains in Norfolk-street and Wood's-mews (one plan, No. 150).

26th March, 1891 (registered No. 181), of intention to lay mains in Park-street, Aldford-street, South-street, Farm-street, Deanery-street, and John-street (one plan, No. 154).

26th March, 1891 (registered No. 182), of intention to lay mains in Market-street, Chapel-street East, Little Stanhope-street, Shepherd-street and Market, Carrington-street, and Whitehorse-street (one plan, No. 155).

26th March, 1891 (registered No. 183), of intention to lay mains in Gilbert-street, Thomas-street, South Molton-street, Sedley-place, Woodstock-street, Blenheim-street, and Dering-street (one plan, No. 156).

26th March, 1891 (registered No. 184), of intention to lay mains in Mill-street (one plan, No. 157).

4th April, 1891 (registered No. 185), of intention to lay mains in Lees-mews and Shepherd's-court (one plan, No. 159).

The proposed works are similar to those sanctioned by the Council on previous notices of this company, and we recommend that the sanction of the Council be given to the works referred to in the six notices (registered Nos. 180 to 185, both inclusive), of the Westminster Electric Supply Corporation, one dated 20th March, three dated 26th March, and one dated 4th April, 1891, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the work in any of the streets specified in the notices; that the mains be laid under the footways wherever it is found practicable to do so; and that the covers of the boxes to be used shall consist of iron frames filled in with material to suit the paving.

The same company has asked sanction to the mains for Grosvenor-crescent being laid on the north side of the thoroughfare, instead of on the south side as shown upon the plan approved by the Council on the 1st April last year (registered No. 68). We see no objection to the proposed alteration; and we recommend that the Council do sanction the laying of the Westminster Electric Supply Corporation's mains on the south side of Grosvenor-crescent instead of on the north side as previously approved.

We have also considered notices (registered Nos. 186 and 187) from the Kensington and Knightsbridge Electric Lighting Company, dated 23rd March and 1st April, 1891, respectively, of proposed extensions of mains in Park-place (one plan, No. 187A), and in Chapel-place (one plan, No. 188A). The proposed works are unobjectionable, and we recommend that the sanction of the

Council be given to the works referred to in the notices (registered Nos. 186 and 187), dated 23rd March and 1st April, 1891, respectively, of the Kensington and Knightsbridge Electric Lighting Company.

The London Electric Supply Corporation has served notices as follows:

26th March, 1891 (registered No. 188), of intention to lay distributing mains in St. Martin's lane and court, Peter's-court, Cecil-court, Cranbourne-street, Great Newport-street, Charing-cross-road, Bear-street, Leicester-square, and Hunt's-court (one plan, D.M. 9/91).
6th April, 1891 (registered No. 189), of intention to lay distributing mains in Great and Little Queen streets, Queen Anne's-gate, Broadway, Great Chapel-street, Tothill-street, Broad Sanctuary, and Little George-street, (one plan, D.M. 10/91).
6th April, 1891 (registered No. 190), of intention to lay distributing mains in Duke-street and Piccadilly (one plan, D.M. 11/91).

These works are of the usual character, and we see no objection to them. We recommend (*a*) That the sanction of the Council be given to the works referred to in the notices (registered Nos. 188, 189, and 190) of the London Electric Supply Corporation, one dated March 26, and two dated April 6, 1891, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the works in any of the specified streets; that the mains for Charing-cross-road be laid and properly protected in the subway there; that the positions to be occupied by the mains in the subway be subject to the approval of the chief engineer of the Council, and that the work of placing them be carried out to his satisfaction; that the mains in the other thoroughfares specified in the notices be laid under the footways, and be kept 9in. below the under side of the paving wherever it is found practicable to do so; that where the mains cross the carriageways they be kept at the same depth below the concrete or the road material as the case may be; and that as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, each insulated from the other as far as practicable, and that the outer cover shall be efficiently connected to earth. (*b*) That the clerk be instructed to forward to the company a notice requiring it to lay the mains for Charing-cross-road, referred to in the notice dated 26th March, 1891 (registered No. 188), in the subway of that thoroughfare.

We have also considered a further notice from the same company, dated 26th March, 1891 (registered No. 191), of intention to lay distributing mains in New and Old Bond streets (one plan, D.M. 8/91). This notice is for a system of low-tension mains with transformers; but the particulars supplied by the company are insufficient, and until further information, which has been asked for, shall have been received, the Council's chief engineer will be unable to report upon the proposed works. In these circumstances we recommend that the Council do formally disapprove the works referred to in the notice (registered No. 191), dated March 26, 1891, of the London Electric Supply Corporation.

We have also to report the receipt of the undermentioned notices, given in accordance with the resolution of the Council to accept four days' (instead of one month's) notice in respect of the laying of service lines from mains already laid:

From the London Electric Supply Corporation:

19th March.—To 12 and 39, Park-lane, and 27 and 29, Norfolk-street.
19th March.—To 57 and 64, Grosvenor-street.
19th March.—To 117, 118, 125, 126, and 127, Piccadilly.
19th March.—To 24, Grosvenor-square.
19th March.—To 98, Piccadilly, and 24, Grosvenor-street.
20th March.—To 3, Grosvenor-square.
23rd March.—To 41 and 43, Brook-street, 90, Piccadilly, and 16, Davies-street.
26th March.—To 24 and 64, Grosvenor-street, and 5, Half Moon-street.
26th March.—To 1, Upper Brook-street, and 23, Grosvenor-square.
26th March.—To 6, Clarges-street, 3, Grosvenor-street, and 72, South Audley-street.
28th March.—To 38, Berkeley-square.
2nd April.—To 19, Grosvenor-square.
4th April.—To 35, Grosvenor-street.

From the Electricity Supply Corporation:

31st March.—To Charing Cross Hotel.

The Electricity Supply Corporation having applied for sanction to an enlargement of the street box in the footway at the corner of Bedford-street, by means of which two boxes in the carriageway of the Strand already sanctioned (registered No. 153), will be rendered unnecessary, we have, in order that the work might not be delayed, given the required sanction to the alteration. We recommend that the course taken by us be approved.

The Notting Hill Electric Lighting Company has given a notice (registered No. 192), dated 7th April, 1891, of proposed extensions of mains in Pembridge-crescent, Holland-park, and Linden-gardens (three plans, Nos. 34A, 35A, and 36A). The proposed works are unobjectionable, and we recommend that the sanction of the Council be given to the works referred to in the notice (registered No. 192), dated 7th April, 1891, of the Notting Hill Electric Lighting Company, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the work; that the coverstones of the culvert shall not be less than 2in. thick; and that where the culvert crosses the carway there shall be at least 9in. thickness of Portland cement concrete above the coverstones of the culvert in addition to the road material.

The same company has called attention to the fact that its supply is by low-tension direct current, and has asked that the requirement attached to the Council's sanction, given on 24th March last, to the works referred to in the company's notice, dated 12th March, 1891 (registered No. 177), that each of the street boxes shall be supplied with an inner as well as an outer cover, may be withdrawn, and that the boxes may be of the pattern previously approved by the Council. As this company's is a low-tension supply, there is no reason for requiring the additional precaution; we recommend that the Notting Hill Electric Lighting Company be informed that the Council will not insist upon compliance with the requirement attached to its consent to the works referred to in the company's notice (registered No. 177), that each of the street boxes should be provided with a second cover, and that boxes of the pattern previously approved be used.

The Metropolitan Electric Supply Company has given a notice, dated 19th March, 1891 (registered No. 193), of intention to lay two service lines in the Strand and Exeter-street (one plan, No. 699). There appears to be no objection to these works, and we recommend that the sanction of the Council be given to the works referred to in the notice (registered No. 193) of the Metropolitan Electric Supply Company, dated March 19, 1891, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the works; that the mains be enclosed in iron pipe or efficient casing, and be laid under the footways wherever it is found practicable to do so; that, as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, insuiated from each other as far as practicable, and that the outer cover, which shall consist of an iron frame filled in with material to suit the paving, shall be efficiently connected to earth.

We have considered a letter from the London Electric Supply Corporation, stating that it is frequently found necessary to lay mains of a different size and description to those specified in the company's notices to the Council; and asking that a general description may be accepted for all sizes of mains, notice being afterwards given of the sectional area to be occupied when it shall have been finally decided which size of main is to be laid. We see no objection to the request of the company being complied with, provided that the company do give in each case sufficient notice as to the size of the main to be used, and that in all cases a general description of the main be sent with the first notice. We recommend that the London Electric Supply Corporation be informed to this effect.

Electric Testing Stations.—We have to report that it being necessary for the purpose of testing electric meters to obtain a supply of current to the electric testing station from the Metropolitan Electric Supply Company, we have given instructions for arrangements being made for such supply, and for the necessary fittings to be obtained at a cost not exceeding £40.

Electric Lighting—Standard Measurements.—We have considered a letter from the secretary of the Electrical Standards Committee of the Board of Trade inviting the Council to suggest the names of one or two gentlemen to give evidence with reference to the adoption of standard measurements. As this is a necessary concomitant of the duty of certifying electric meters and mains, we have retained Prof. Silvanus Thompson, who has acted as our adviser in connection with the equipment of the Council's electric testing station, to attend and give evidence before the committee.

LEGAL INTELLIGENCE.

VERITY AND SONS v. TERRY.

"New Lamps for Old."

This was an action to recover £593. 0s. 6d. for work done by the plantiffs as electric lighting engineers, and came before Mr. Justice Charles in the Queen's Bench Division on Monday.

Mr. J. F. Moulton, Q.C., and Mr. S. O. Buckmaster appeared for the plaintiff, and Mr. Cyril Dodd, Q.C., and Mr. T. J. Bullen for the defendant.

The defendant was the well-known comedian, and the work was done for his theatre in the Strand. The plaintiffs' claim was for the installation of the electric light in the theatre, and various other sums for lamps, brackets, and other goods supplied in connection with the work. The defendant pleaded that the plaintiffs had agreed to improve and repair the existing electric lighting at his theatre, and supply the whole of the materials for the sum of £125, and to supply 15 additional lights in the defendant's offices, and an electrolier in the saloon bar of the theatre for the sum of £22. 15s. The defendant alleged, further, that any work done or goods supplied other than the 15 additional lights and the electrolier was done or were supplied without his authority or knowledge, and paid £27. 15s. into court (having already paid plaintiffs the sum of £120) as sufficient to answer the plaintiffs' claim.

Mr. G. H. Verity, one of the plaintiff firm, in his evidence, said all the orders came from Mr. Bricknell, the defendant's agent. He went over the place and pointed out where all lights were to be put. They worked night and day to have the installation ready before a piece called "New Lamps for Old" was produced. Nothing had been done without orders from Mr. Bricknell.

Mr. Cunnington, Mr. Verity's engineer, corroborated this evidence.

Mr. Edward O'Connor Terry stated t[illegible] of Terry's Theatre. He let his th[illegible] somebody on behalf of M[illegible]

Lamps for Old." He left London for India in January, 1890. Up to this time he had spent some hundreds of pounds in electric lighting at his theatre with satisfactory results. When he let the theatre he communicated with the plaintiff about improving the electric lighting. The plaintiffs' estimate or report was brought to him before he left England, and he accepted it. He never gave Mr. Bricknell any authority to vary this estimate in any way. His attention was first called to the increased work in the third week in May after his return. He repudiated the claim in June. The plaintiff came to his office and explained that on overhauling the work he found it was more than he anticipated. The plaintiff said nobody had given him orders for the extra work, and that he did the work through a mistake. Witness (Mr. Terry) then told plaintiff he could not be responsible for that, but agreed, however, to pay for the 15 lights and the electrolier, and suggested that perhaps it would be fair to pay £150 to the plaintiff, but this was not agreed to.

At this stage of the case, by suggestion of the learned Judge, the counsel engaged conferred with him in his private room, and his Lordship, on their return, intimated that he was pleased to say that the parties had come to an arrangement, whereby the defendant was to pay to the plaintiff £375, including the amount paid into court and paid to plaintiff already.

The learned **Judge** said he thought the plaintiffs were not to blame in any way for what had occurred, and that Mr. Terry had electric lighting in his theatre equal to any in London; but as the work had been done while Mr. Terry was absent his surprise at the amount of the bill was natural. The work had been well done and the prices were fair, and under all the circumstances the learned Judge thought the defendant ought to pay the costs of the action.

Judgment accordingly.

SAVORY AND MOORE v. THE LONDON ELECTRIC SUPPLY CORPORATION.

Is the High-Pressure System a "Nuisance"?

This action came before Mr. Justice Kekewich in the Chancery Division of the High Court of Justice on Tuesday and Wednesday in the shape of an application by the plaintiffs, who are chemists of Bond-street, for an injunction to restrain the corporation from so carrying on their business as to be a nuisance, the nuisance consisting of the danger from fire to the plaintiff's premises, where a large quantity of inflammable drugs and other goods were stored, in consequence of the high-pressure system used by the defendants.

The plaintiffs' case was that, in consequence of the use of the high-pressure system, there was great danger from fire from the defendants' distributing centre in Grosvenor-mews, where they received current from their generating station at Deptford. It was stated that a number of accidents had already occurred at the Bond-street works, and that there had been at least one serious fire on the defendants' premises. The London Electric Supply replied that when the accidents and fire occurred their Bond-street station was only temporarily fitted up, but now the transforming station was made entirely fireproof, so that under no circumstances could a fire occur again, as there was nothing combustible in the room.

His **Lordship** directed the action to stand over for three months, with a view to seeing whether the defendant corporation would take extra precautions to prevent any danger from fire, or otherwise, arising from the use of the upper portions of their building into which electrical appliances might be introduced. He was not satisfied that the upper floors were fireproof, but thought the defendants should have proper time to render them so.

Mr. C. M. Warmington, Q.C., and Mr. Vernon Smith were counsel for the plaintiffs, while Mr. Fletcher Moulton, Q.C., represented the defendant corporation.

JABLOCHKOFF'S PATENT (ELECTRIC LIGHT).

Before the Judicial Committee of the Privy Council on Wednesday.

This was a petition of the Electrical Engineering Corporation, Limited, for the prolongation of letters patent dated May 22, 1887, granted to Mr. Paul Jablochkoff for the invention of "a new process of producing and dividing electric light and apparatus therefor."

Mr. Moulton, Q.C., and Mr. Roger Wallace were counsel for the petitioners; Mr. Henry Sutton for the Crown.

Mr. Moulton said he was obliged to put before their Lordships a difficulty in his way which his clients had only learned within the last few days—namely, that the opponents were going to bring before the Judicial Committee a certain prior publication which they alleged anticipated his client's patent—viz., a paper read at a meeting of the Society of Telegraph Engineers on May 9, 1877. The paper was communicated by some unknown person, and without Mr. Jablochkoff having anything to do with it. Consequently, he was obliged to admit that that prior publication rendered the patent invalid unless there should be a confirmation under the powers of the statute 5 and 6 William IV., c. 82, sec. 2. He asked their Lordships to allow him to amend the petition by adding a prayer for confirmation, or he invited them to prolong the patent on the present petition, he undertaking that, until confirmation, no claims should be made thereunder.

After some discussion, their **Lordships** suggested that the matter should stand over for a time, so that Mr. Moulton's clients might consider what steps they should take as to filing a fresh petition.

Mr. Moulton acceded to this course, and the matter was accordingly adjourned.

COMPANIES' MEETINGS.

SOUTH OF ENGLAND TELEPHONE COMPANY.

At an extraordinary general meeting of the shareholders of this Company held at Winchester House on Monday, Mr. Bateson, chairman, presiding, the resolutions passed at the extraordinary meeting on 16th March, transferring the business of the Company to the National Telephone Company, were confirmed.

The following resolutions were put from the chair and carried unanimously:

"(1) That the remuneration of the Directors for the past year be fixed at a sum of £200.

"(2) That the purchase consideration to be received by the liquidator under the above agreement (for transfer of the business to the National Company) be distributed among the members as follows: (*a*) As to the cash portion of such consideration, (1) in repayment of £2,992, the amount of money paid in advance of calls on the preference shares, (2) of interest on the same sum at the rate of 5 per cent. per annum, from the 1st November, 1890, to the time of such repayment, and (3) the balance in payment of a sum equal to 6 per cent. per annum on the amount paid up on the preference shares, from the 1st November, 1890, to the date when the debenture stock hereinafter mentioned commences to carry interest. (*b*) As to £70,000 $4\frac{1}{2}$ per cent. debenture stock of the National Company, by distributing the same among the holders of the preference shares according to the amounts paid up on such shares otherwise than in advance of calls. (*c*) As to the 12,000 fully paid ordinary shares of the National Company, by distributing the same among the holders of the ordinary shares of this Company, according to the number of such shares held by them respectively."

The proceedings only lasted a few minutes, and there was a very small attendance.

ORIENTAL TELEPHONE COMPANY.

The eleventh ordinary general meeting of this Company was held on Wednesday at Cannon-street Hotel, the chairman, Mr. William Addison, presiding.

The report (*vide* our last issue) having been taken as read, the **Chairman** said that he had again the pleasure of announcing continued progress in the business of the Company, though it was true that such progress was not so rapid as could be wished owing to the difficulties they had to contend with in extending their operations. This was especially the case in India, the Telegraph Department of the Government of India being unwilling to allow the facilities which were necessary to the success of their subsidiary companies in that country. However, notwithstanding the restrictions against which those companies had to contend he was glad to be able to report an increase in their dividends this year amounting to $\frac{1}{2}$ per cent. on the Bengal Company's shares, and 1 per cent. on the Bombay shares, making $2\frac{1}{4}$ per cent. free of income tax. This result was in some measure attributable to economy of management. Their exchanges at Singapore and Rangoon showed a small improvement in revenue. The Directors of the Telephone Company of Egypt, after paying the interest on their debentures, had declared a dividend of 6 per cent. It was with great regret he had to announce the loss by death of their colleague the Right Hon. G. A. F. Cavendish Bentinck, M.P., who had been on the Board for five or six years. To comply with the articles Mr. Lloyd retired in place of Mr. Bentinck and offered himself for re-election. As to a distribution of a dividend, the Directors had been in negotiation with a large holder of vendors' shares to try and arrange for the placing of the capital on a common footing. In the course of these negotiations an actuary who was called in raised an important question as to the mode in which the profits were divisible. Counsel's opinion was taken, and after due consideration the accounts had been prepared in the form then before the shareholders. Since the issue of the report proceedings had been taken by a holder of vendors' shares, the nature of which would be explained by the solicitor.

Mr. Joseph Addison (solicitor to the Company) then explained the method of declaring dividends, and said that only the dividends upon the vendors' shares should go to make up the deficiency on the first five years to the ordinary shares. If that contention was upheld it would make a very large difference in favour of the ordinary shares as against vendors', because that deficiency would have to be made up solely out of dividends declared upon vendors shares, instead of adding together the dividends upon ordinary and vendors' shares. This view of the matter was not very agreeable to the holders of the latter shares, and a very large holder of them had thought fit to challenge it, and had taken proceedings in the Courts, which would come on on Friday. These were not taken with a view to stopping the payment of a dividend, but of getting the Court to decide which was the right construction of the agreement. The Directors did not express an opinion upon the question, although they had adopted that course. They represented the Company as a body, and the rights of both classes of shareholders would be properly protected.

The **Chairman** then moved the adoption of the report and accounts.

In answer to questions the **Solicitor** stated that the deficiency on February 4, 1886, when the five years came to an end, was about £20,000. He then read a clause in the agreement for the drawing of which he was not responsible, to the effect that during five years from February 4, 1881, the holders of vendors' shares would not participate in the profits of those years until the ordinary shares received 6 per cent. in each year, which, he added, they did not do. The question was whether the holders of ordinary shares were entitled to receive their share of the profits of subsequent years without counting those profits towards the £20,000.

Mr. Hibbert pointed out that the shares of the Company were never quoted, and yet they were a very good investment.

The motion was then seconded by **Mr. St. John Ackers**, and carried unanimously.

Mr. Cheston, on behalf of the holders of vendors' shares, protested against the method of declaring the dividend. The whole of the dividend earned by the Company should be applied in wiping off the deficiency.

The retiring directors, Messrs. St. John Ackers and Lloyd, and the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., having been unanimously re-elected,

The **Chairman** brought forward the question of altering the articles of association in order to enable them to supply electrical apparatus and material generally. It was not their intention to depart from the business they were now engaged in; but they had been asked to supply various apparatus from time to time, and had been obliged to decline.

In answer to questions, he said the proposed alterations would require no further capital or expenditure.

The **Solicitor** having read the proposed alterations which related to the generation, employment or utilisation of electricity or magnetism, and the ability to carry on any business or manufacture connected therewith, a resolution making the alterations was moved from the chair and carried unanimously.

A vote of thanks to the Chairman closed the proceedings.

AN ASSOCIATION OF TELEPHONE SUBSCRIBERS.

A meeting of London telephone subscribers was held at Cannon-street Hotel on Wednesday afternoon, to take such steps as might be advisable in their interests.

Mr. Hastie, of Lincoln's-inn-fields, having been voted to the chair, said that he was responsible for calling them together. He had been a subscriber to the telephone for several years at his office and private house, and had been more fortunate than others from whom he had received great complaints of ineffective service, for, with the exception of the first few months, he had found nothing of the kind. He had a very good service at a very high price. Whatever the price was, he took it, they must have the telephone. What made him make complaints was that he saw from a report of the last meeting of the National Telephone Company that the chairman ventured to tell his shareholders that there was no occasion to reduce the price. But they (the company) were serving a very bad article at a high price. He (the Chairman) knew he was paying too much. He paid £20 a year for his office telephone, and £12 for his house connection. He felt sure the company did not lose anything over the latter, and therefore they could afford to supply the telephone for £12 a year. (A Voice: Less.) That price was the maximum charge upon which he proposed they should insist. He had no wish to promote a company, but had come there merely as a subscriber to try and get them all to stick together and have the same power of dealing with the telephone company that it had in dealing with them. He had received subscriptions to the association, in amounts of 5s., reaching a total of £98, which represented as nearly as possible 400 members, and he found there would be no difficulty in getting probably half the subscribers to the telephone to join, because where they would not join the association if he asked them they would when asked by a friend whom they knew. The question to decide was whether they should establish a permanent association to which complaints of the telephone service could be addressed, and which could keep the company in order, or whether they should confine themselves to reducing the charges. He had communicated with the Postmaster-General, and had had a letter from him in which he said that he could not be indifferent to a clearly-expressed and general demand for the establishment by his department of a telephone service in London, but he regarded it as premature at present to state what the charges for such a service would be. That, said the Chairman, showed quite plainly that if the telephone company would not do it, the Postmaster-General was quite ready to undertake it himself. The general feeling of the Chamber of Commerce was in favour of a movement of that kind, and the matter would be brought forward at its meeting next week. He would venture to suggest that the first resolution should be that an association of that kind should be formed, and, secondly, that a committee should be appointed to put the thing into shape and deal with the telephone company at once. With regard to the money he had received, he had £54 in hand after paying expenses.

Mr. R. W. Leage having criticised the telephone service, thought £12 a year was a full and sufficient premium to pay for it, and at that price the company would get more business and subscribers. He moved that an association be formed for the protection of the telephone subscribers of London and neighbourhood.

Mr. Goddard Clark said that his firm had determined to co-operate with Mr. Hastie in this matter. They had issued circulars asking for particulars of the telephone service in provincial towns in England and Scotland. The bulk of the replies stated that they had had their rates reduced from £20 to £15, £15 to £10, and some £10 to £5 within a recent period. If this could be done in the country, why could it not be done in London? He then read a list of the rates current in various towns, with the recent reduction—Blackburn £10, Bradford £10, reduced from £15 (this includes communication with Skipton), Derby £10 (includes Belper), Glasgow £10 from £15, Leeds £10 from £15, Liverpool £15 from £20 (includes Birkenhead), Manchester £10 (another company charged £6. 6s.). He seconded the resolution, which was carried unanimously.

Mr. Collins remarked that in Berlin they only paid £7 a year for a more effective service.

Mr. Leage then proposed that a committee be formed to carry out the above resolution, which was seconded and carried unanimously.

One speaker suggested that they should strengthen their numbers before acting, so as to make their weapon (the Association) as powerful as possible; and that the committee should not attempt to deal with the telephone company until they had got the support of more subscribers. He thought the point that touched them was not the price of the service, but the dissatisfaction they got from the company.

Another speaker said that his dissatisfaction with the telephone service was so great, that he took shares in order to make complaints.

Mr. F. L. Rawson thought that this should be a provisional committee and appoint the ultimate committee, and added a word in defence of the telephone operators, who had been hardly spoken of by a previous speaker.

It was explained that the committee was understood to be only provisional, and with power to add to their number. Several names were then proposed as members of the committee, among them being Messrs. J. J. Ball, Goddard Clark, W. C. Jackson, Tyler, R. W. Leage, F. L. Rawson, I. J. Collins, J. D. Copeland, C. R. Hague, and the Chairman. These were put *en bloc*, and carried unanimously.

The **Chairman** asked if they would indicate the lines on which the committee should work.

A **Member** thought they had better wait till they were more organised before taking definite steps with regard to the telephone company, though he did not think they should be deterred from entering into negotiations.

Mr. F. L. Rawson considered that the appointment of a committee of that sort, whilst, perhaps, acting as a thorn in the company's side, would really be of great use to them, because when the telephone subscribers knew that there was a committee appointed to look after their interests, they would know that what could be done by the telephone company was being done. As to comparison with other countries, they were altogether in a different position here, and there were a great many difficulties to get over not due to the fault of the company; therefore he did not feel that they were in opposition to the company in any way, but only had to appoint a committee to see that the interests of subscribers were protected as far as possible.

Another speaker instanced as one of the difficulties to be met by the telephone company the obstructive tactics of the vestries; and another pointed to the fact that no telephone line could be run along the underground railway unless the Postmaster-General's instruments were used. He thought the Government were worse than the vestries.

Mr. F. L. Rawson urged that pressure should be brought to bear on the Post Office to allow subscribers to the London telephone service to be connected direct to the Paris-London telephone line. If this had been possible within the past few weeks, he could saved several hundred pounds. He moved a resolution to this effect, which was carried unanimously.

In answer to further questions, the **Chairman** said that he apprehended that the committee would do what they could and report to a future meeting, of which due notice would be given.

A hearty vote of thanks to the Chairman closed the proceedings.

COMPANIES' REPORTS.

INDO-EUROPEAN TELEGRAPH COMPANY.

The report shows that the revenue from all sources for 1890 amounted to £113,807, an increase of £5,518, and the expenses to £57,901, a decrease of £1,338; and, after taking credit for £2,035 brought from 1889, and debiting income tax, there remains £56,668. From this amount £10,000 has been placed to reserve, and £10,625, amount of interim dividend, has to be deducted, leaving a balance of £36,043. The Directors propose a dividend for the six months ending December 31st of 17s. 6d. per share, making, with the dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, both tax free, making in all 10 per cent., and carrying forward £4,168.

EASTERN EXTENSION TELEGRAPH COMPANY.

The report for the half-year ended December 31 states that the gross receipts, including Government subsidies, amounted to £279,095, against £264,103. The working and other expenses, including £23,118 for cost of repairs to cables and expenses of ships, absorbed £74,090, against £73,499; £35,281 was required for interest, and £100,000 has been charged on account of the cost of duplicating the Madras-Penang cable, leaving £65,687, which with £71,820 brought forward, shows an available balance of £137,507. One quarterly interim dividend of 1¼ per cent. has been paid, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent.

or the year 1890. The balance of £25,007 has been carried to the general reserve fund, which, after being credited with interest and profit on sale of investments, and debited with £10,722 on account of the cable renewals, etc., now stands at £495,239. Since the close of the year nearly the whole of the 6 per cent. debentures have been paid off.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £5,918.

City and South London Railway.—The receipts for the week ended 11th inst. were £827, as compared with £901 for the week ended April 4 (Bank Holiday week).

Western and Brazilian Telegraph Company.—The receipts for the week ended April 10, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,777.

Direct United States Cable Company.—The Directors recommend the payment of an interim dividend of 3s. 6d. per share, tax free, being at the rate of 3½ per cent. per annum for the quarter ending March 31, payable on and after the 24th inst.

Sutton-in-Ashfield.—We notice that the tender of Mr. G. Jennings, of Lambeth, has been accepted by the Local Board for providing and fixing patent electro-mechanical apparatus for indicating and recording in pumping station the level of water in reservoir.

Anglo-American Telegraph Company.—The Directors have declared an interim dividend for the quarter ended March 31 of 12s. per cent. on the ordinary and 24s. per cent. on the preferred stock, less income tax, payable on May 1 to the stockholders registered on April 7, 1891.

Great Northern Telegraph Company.—From the accounts of this Company for the year 1890 it appears that after providing for the interim dividend of 5 per cent. per annum, and an extra dividend of 7s. 2d. per share, and also adding £66,666 to the reserve fund, a balance of £48,216 will remain to be carried forward.

Reuter's Telegram Company.—Mr. Justice Chitty has confirmed a special resolution passed by Reuter's Telegram Company, authorising the Company to effect an alteration in its memorandum of association, with the object of extending its business so as to include that of supplying a telephonic news service and that of advertising contractors and agents in all its branches.

Messrs. Johnson, Matthey, and Co., the old-established firm of assayers and refiners of the precious metals, have decided to register themselves as a joint stock company. The nominal capital (ordinary and preference shares in equal moieties) is £900,000, of which £750,000 is now issued, and £600,000 paid up, leaving an uncalled liability on the ordinary shares of £150,000. The whole of the issued capital is taken up by the members of the firm, who will continue to manage the business as directors, and no change is contemplated in the character of its operations. The Company acquires the business as from January 1 last. The following gentlemen will form the Company: G. Matthey, J. S. Sellon, E. Matthey, R. D. Matthey, J. S. Pybus-Sellon, C. G. R. Matthey, P. St. C. Matthey, and R. S. Sellon.

PROVISIONAL PATENTS, 1891.

APRIL 6.

5869. **Improvements in indicators for electric bells, or for the passage of electric currents.** George Scarlett, 6, Lord-street, Liverpool.

5903. **An electro-pneumatic rock drill.** James Walter, Viscount Grimston, 28, Southampton-buildings, London.

5912. **Improvements in the transmission of electricity to portable cranes and other machinery, telpher lines, and the like.** William Danton Sandwell, 4, South-street, Finsbury, London.

5918. **Improvements in electric batteries.** Henry Inkson Harris and Willoughby Hamilton Power, 22, Southampton-buildings, London.

APRIL 7.

5947. **Method of and means for renewing or repairing the filaments of incandescent electric lamps.** Harry Chapman, 8, Quality-court, London.

5953. **Improvements in and relating to voltaic batteries.** William Ascroft Byron and Edgar George, 8, Old Jewry, London.

5963. **An electric "hooter" or loud sound producing apparatus.** Henry Alfred Charles Saunders and Alfred Charles Brown, 9, Warwick-court, High Holborn, London. (Complete specification.)

5972. **Improvements in electric storage batteries.** William Sillery, 6, Lord-street, Liverpool.

5989. **An improved means of wiring brackets, pendants, electroliers, and the like for electric lighting.** Edward William Lancaster, Albert Works, Graham-street, Birmingham.

5983. **Improvements in or connected with means or apparatus employed in electrolysis.** Ernest Arthur Le Suer, 47, Lincoln's-inn-fields, London. (Complete specification.)

5992. **Improvements in pneumo-dynamometers.** François Edmond Savary D'Odiardi, 54, Fleet-street, London.

5993. **Improvements in the electric cup.** François Edmond Savary D'Odiardi, 54, Fleet-street, London.

5994. **Improvements in electro-inhalers.** François Edmond Savary D'Odiardi, 54, Fleet-street, London.

5995. **Improvements in liquid electrodes.** François Edmond Savary D'Odiardi, 54, Fleet-street, London.

5996. **Improvements in magneto-voltaic and static electrodes.** François Edmond Savary D'Odiardi, 54, Fleet-street, London.

5997. **Improvements in electric atomisers.** François Edmond Savary D'Odiardi, 54, Fleet-street, London.

6003. **Terminals for cables of electrical conductors.** John Cecil Reilly, 24, Southampton-buildings, London. (Complete specification.)

6007. **Improvements in handles or taps for electrical switches.** Edward William Lancaster, Albert Works, Graham-street, Birmingham.

APRIL 8.

6011. **Improvements in ceiling roses for electric lighting.** Andreas Peter Lundberg, 18, Fulham-place, Paddington, London.

6012. **Improvements in switches for electric lighting** Andreas Peter Lundberg, 18, Fulham-place, Paddington, London.

6029. **Improvements in electro-depositing copper, brass, and bronze, parts of which improvements are also applicable to other purposes.** William Henry Walenn and Illius Augustus Timmis, 2, Great George-street, Westminster.

6030. **Improvements in electro-depositing copper, brass, or bronze.** William Henry Walenn and Illius Augustus Timmis, 2, Great George-street, Westminster.

6048. **Improvements in electric power apparatus.** George North, 323, High Holborn, London.

6072. **Improvements in electro-heating apparatus.** Charles Edwin Carpenter, 45, Southampton-buildings, London. (Date applied for under Patents Act, 1883, sec. 103, 27th September, 1890, being date of application in United States.) (Complete specification.)

APRIL 9.

6104. **Improvements in dynamos and motors.** Illius Augustus Timmis and Alfred Ivor Smith, 2, Great George-street, Westminster.

6125. **Improvements in electrical apparatus for soldering, boiling, and heating.** Johann Jakob Ritter, 4, South-street, Finsbury, London. (Complete specification.)

APRIL 11.

6194. **Improvements in electromotors for alternating currents.** John Augustine Kingdon, 29, Marlborough-hill, London.

6232. **Improvements in microphones for telephonic circuits, and in the induction coils thereof.** Eugene Gwosdeff and Andréas Bunge, 28, Southampton-buildings, London.

6243. **Improvements in galvanic batteries.** Siegfried Marcus Louis Patz and Rudolf Grebner, 46, Lincoln's-inn-fields, London.

SPECIFICATIONS PUBLISHED.

1889.

19835. **Electrical signalling.** Perls. (Second edition.) 1s. 1d.

1890.

4650. **Producing motion by electricity.** Palmer. 11d.

4824. **Dynamo-electric machines.** Nebel. 8d.

5923. **Electric currents.** Sleeman. 8d.

13463. **Galvanic batteries.** Moseley. 8d.

19942. **Galvanic batteries.** Thompson (Marx). 6d.

20986. **Electrically welding, etc., metals.** Lake (Lemp). 8d.

1891.

641. **Electric clocks.** Hammer. 8d.

908. **Insulators for electric wires.** Ross. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¼
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Bromley.—Steps are being taken to present the Bromley Electric Lighting Order to Parliament.

Telephone in Leek.—The National Telephone Company are trying to start an exchange at Leek.

Electric Welding.—A Thomson welding plant is to be used at the Pullman Car Works, at Pullman, Illinois.

Central London Railway.—In the House of Commons on Monday, the Central London Railway Bill was read a third time.

Leeds Tramway.—It has been decided that the Thomson-Houston Company may charge 2d. instead of 1d. for the fare on the Roundhay line when completed.

Telephoning to Brussels.—Telephone experiments between London and Marseilles and London and Brussels were made on Sunday, and, being satisfactory, are to be continued.

Society of Arts.—On Wednesday next, April 29, Prof. William Robinson will give a paper on "The Use of Petroleum in Prime Motors." Prof. Silvanus Thompson will preside.

Projecting Frontages.—The City and South London Company's lawsuit with the London County Council *re* projecting frontages, has been allowed to be carried to a higher court.

Telephone to Bordeaux.—A telephone line is shortly to be opened from Paris to Bordeaux, and £2,600 has been paid over by the Chamber of Commerce to the French Telegraph Department.

Ether and Electricity.—Among the numerous papers submitted to the Congrès Scientifique International des Catholiques, was one by M. Le Corquillé, of Rennes, upon "L'Ether et l'Electricité."

Glasgow Technical College.—Sir Wm. Thomson has intimated that, owing to the engrossing nature of his engagements, he must resign his position as governor of the Glasgow Technical College.

Contades Arc Lamp.—In the arc lamp used by M. Contades for lighthouses, the focus is kept by a right and left handed screw carrying the carbons, the pitch of the top screw being double that of the lower.

Crystal Palace District.—The Board of Trade have extended the time by three months for the promoters of the Crystal Palace and District Electric Lighting Company to comply with the eighth section of their order.

Papers.—At the Civil Engineers to-night (Friday) Mr. A. Sealey will read a paper on "A New Type of Water Motor." On Saturday Dr. Thompson will give his third lecture before the Royal Institution on "The Dynamo."

Brush Co.—We are informed that His Grace the Duke of Marlborough has accepted the position of chairman of the Brush Electrical Engineering Company, Limited, in succession to Lord Thurlow, who has resigned his seat at the board of that company.

Smoking Concert.—The Old Students' Association will hold a smoking concert to-night (Friday) at Masons' Hall Tavern, Basinghall-street, at 7.30 p.m. The programme includes some high-class vocal and instrumental music, besides humorous selections.

Alsacian Dynamos.—The central station of the Rue des Dames, Paris (Secteur de la Place Clichy), has three slow-speed (250 revolutions) dynamos of the Société Alsacienne, with interior poles, giving 800 amperes at 200 volts, driven direct by 500-h.p. Corliss engines.

Dobrowolski Motors.—It is hoped in about a month that a 10-h.p. Dobrowolski rotary-current motor will be sent over from the Allgemeine Company to the Keys' Electric Company, which will be carefully tested by Prof. Fleming, Mr. Kapp, and Mr. Reckenzaun.

Rome.—The last report of the Anglo-Roman Gas Company mentions that the central electric station of the company at Rome comprises four dynamos of 600 h.p. and two of 150 h.p.; that the number of lamps of 8 c.p. supplied is 33,000, an increase of 12,000 during 1890.

London Electric Railways.—Mr. M. C. Greenhill, 11, Queen Victoria-street, asks whether it would not be well for some responsible authority, such as the London County Council, to map out London for a good electric railway system before any more "patchwork" is attempted.

Woolwich.—On the motion of the Rev. J. W. Horsley, at the meeting of the Woolwich Guardians, it was resolved that an estimate of the cost of lighting the Board-room with the electric light be obtained, the gas which is in use causing a disagreeably high temperature and a poisonous atmosphere.

Camberwell.—The General Purposes Committee of the Camberwell Vestry reported upon the Camberwell electric lighting provisional order, and recommended that the Board of Trade be informed that, subject to certain omissions, the Vestry had no objection to the form of the proposed order.

Artificial Mountain.—At the Chicago Exhibition it is proposed to construct an artificial mountain, with steel girders and network covered with concrete shaped like rocks. An electric mountain railroad is to wind its way to the summit, and the interior would be lighted by electric light and used for exhibition purposes.

Lubricants.—At the meeting of the Andersonian Chemical Society, Glasgow, a paper was read by Mr. John M'Adam, on the "Action of Oils on Metals." The lecturer gave the results of some months' work in determining the corrosive action of various lubricating oils on metals under ordinary working conditions.

Liverpool Tramways.—A splendid double-motor accumulator car has been despatched by the General Electric Traction and Power Company for use on the Liverpool tramways. The car contains two 10-h.p. motors, and is capable of running up to the long gradients of one in 20 to 30 that are met with on the Liverpool lines.

Safety Commutator.—A Davis and Stokes safety commutator for dynamos and motors is running successfully at All Saints' Works, Derby, where the motor is applied to a pump. As the machine is destined for a colliery which is difficult of access, Messrs. Davis have had the motor on exhibition to any engineer who may be interested.

French Cables.—The submarine cable factory of the Société des Téléphones at Calais was opened last week. Three hundred workmen were employed, and there are orders in hand to last several years at the rate of 500 miles of cable a month. The 90 visitors invited from Paris lunched on board the "Westmeath," which has the West Indies cable on board.

Depredations.—Messrs. O. Berend and Co. wish it to be understood that they believe some hundreds of letters have been wilfully destroyed by employés prosecuted by them at Guildhall last week, and in many cases enclosures and orders for goods may have never come into their possession. Clients not having received answers should again communicate.

Glasgow Tramways.—The Glasgow Tramway Company are bringing the question of electric cars before the House of Lords. They maintain that electric traction is not suitable for street traffic, and the Glasgow Town Council say it is. If the Corporation are satisfied of the utility, it stands to reason the tramway company will have difficulty in proving their adverse contentions.

Filter Papers.—A novelty in filter papers is being introduced by Messrs. Charles Schleicher and Schüll, whose London agents are Messrs. Townson and Mercer. These papers possess, even in a damp state, a hardness and durability which almost equals that of parchment, and the sediment in chemical testing can be easily scraped off, whilst the paper can be worked and used many times.

Leek (Staffs.).—The Electric Lighting Committee of the Leek Improvement Commissioners recommended that circulars should be issued to householders and manufacturers asking them if they would be prepared to adopt the electric light if the cost would not be more than 25 per cent. above the present price of gas. This recommendation being opposed, and only five voting for it, was declared not carried.

Finchley.—At the meeting of the Finchley Local Board the question of a provisional order for the district came up, and Mr. Hook discussed the advantages of the Board obtaining the rights for themselves. He moved that a provisional order be obtained. The chairman ruled that it would be necessary to call a special meeting, and to give a month's notice before such a resolution could be brought forward, and a motion was accordingly carried to call such a meeting.

Press Guide.—We have received a copy of Willing's British and Irish Press Guide for 1891 (162, Piccadilly, 1s.) which gives in convenient space a very complete list of newspapers, journals, and magazines, with much other information relating thereto. It will hardly be credited, perhaps, by our readers, that so far as technical journals are concerned this guide is more correct and up to date than even the electrical directory itself, also issued yearly by a technical contemporary.

Brush City Showrooms.—The Brush Company have now got into their City showrooms, and are making quite a handsome exhibition of the corner shop opposite the Mansion House Station, where prettily draped and illuminated Mordey alternators, Victoria dynamos, and switches, fittings, and lamps of all descriptions are eagerly being inspected by City gentlemen, at whose doors the current will be laid on before very long. Messrs. J. Bate and T. Webb-Watt are the managers of this department.

Provisional Orders.—The Board of Trade has made provisional orders under the Electric Lighting Acts, relating to Bolton, Canterbury, Dewsbury, Hanley, Harrogate, Sunderland, Ealing, Norwich, Southport, Stockport, Surbiton, Tynemouth, Bishop Stortford, Croydon, Heckmondwike, Londonderry, Southend, Weston-super-Mare, Acton, Chiswick, Coventry, Kidderminster, Llanelly, and South Shields. These orders have been embodied in Bills which are to be submitted to Parliament for confirmation.

Electric Launches for Russia.—The General Electric Traction Company have just been commissioned by Captain Zelonoi, naval attaché to the Russian Embassy, for an electric launch 40ft. long, fitted with all the newest improvements. The order for the construction of the boat has been placed with White, of Cowes, who are also building a service pinnace for the company to be exhibited at the forthcoming Naval Exhibition at Chelsea. It is expected that the above-mentioned launch for Russia is merely the first of a series.

Amble.—A communication was received by the Amble Local Board last week, from Messrs. Nicholson and Jennings, electrical engineers, stating the terms upon which Amble could be lighted with electricity. The installation of 16 2,000-c.p. nominal arc lamps, with plant complete, would cost £1,124, and the working expenses would be £4. 11s. per week. The repayment of the cost could extend over a term of five, 10, or 15 years, 5 per cent. being charged on the unpaid capital. The communication was laid on the table.

Lyons.—As we have mentioned, a project has been formed at Lyons for the utilisation of the water power of the Rhone for the transmission of 10,000 h.p. It now appears, according to a note in *Electricité*, that the authorities consider the sanction of law is necessary before the work can be begun. They also consider it will be two years before this sanction can be obtained! This is one of the beauties of a Republic which still lies bound under the stress of a Napoleonic administration while posing under the guise of true democracy.

Electric Tramcars for London.—We are able to state that the contract for the electric cars at Barking-road, the plant not being able to be taken over by the company, has been renewed with the General Electric Traction Company at 1d. per car mile extra—that is, at 5½d. per car mile. The application to Parliament for powers to run at West Ham will be renewed next year. Meanwhile, we believe the North Metropolitan Company intend making arrangements for working some of their lines into Moorgate-street by means of accumulator cars.

Electrical Engraving.—Has anyone made a practical application of M. Planté's method of engraving on glass and crystal? This is a question we are asked, and we shall be pleased to learn of any development. M. Planté's method, it may be remembered, is to cover the plate with a concentrated solution of nitrate of potash, connected to one pole of a battery, the design being traced by a platinum point connected to the other pole. A quick method for making process blocks for printing in newspapers might, it is suggested, possibly be thus elaborated.

Leamington.—At the Leamington Town Council meeting on Monday, the clerk reported his discussion with the Board of Trade with reference to the Corporation's application for a provisional order. They could have no order without purchasing the plant or allowing the present company to compete. Councillor Crowther Davies moved that the Council have full power to drop the application, and this was carried. Councillor Fell thought that a clause should be inserted in the company's application giving the public the advantage of any cheapening in the process, but this was not accepted.

Windermere Electric Launches.—Four electric launches driven by Immisch motors, similar to those run at Edinburgh, are running on Lake Windermere. A secluded waterfall of 60 h.p. has been secured at Cunsey, hitherto used for a reel mill, and a dynamo has been put down. This is sufficient to charge eight such launches instead of four, and others will doubtless be added. The open lake is eminently suited for pleasure excursions at speeds of six to 10 miles an hour, and the enterprise will doubtless lead to the institution of silent electric launches upon other of these lovely lakes.

Telephoning in French.—An amusing example of the little mistakes that were only too likely to be made at first on the Paris telephone comes to us in a roundabout way from an Italian technical paper. It seems that an English correspondent wished to telephone to Paris that there was a grand success at the Prince of Wales Theatre of "L'Enfant Prodigue." This he had pronounced "L'Onfong Proddigg, Prangce of Wales," which the French reporter at the other end, not being accustomed to the English accent, so it is said, took for English "Hong Kong, strong gale"—that is, for a notification of a storm at Hong Kong!

Platinum and Palladium Crystals.—Mr. Joly, of Trinity College, Dublin, says the *Globe*, gives the following method of obtaining crystals of platinum and palladium. A ribbon of the pure metal is stretched horizontally between two binding screws and dusted with powdered topaz. An electric current is then passed through the ribbon, which is thereby raised to a red heat. In about half an hour the current is stopped, and the ribbon examined by a microscope. Small brilliant crystals of the metal are seen to have formed on the topaz. If the heating be kept up longer, these crystals will grow to the size of a millimetre in length.

Electricity in Mines.—About 30 members of the South Staffordshire branch of the National Association of Colliery Managers met at the Great Wyrley Colliery on Tuesday, and were received by Mr. C. Browell, president of the branch, and conducted through the workings. At the pit bottom, Mr. F. Brown, of the Walsall Electrical Company, read a practical and valuable paper on "Electricity as Applied to Mines," and illustrated his subject with a number of interesting experiments. The visitors were subsequently entertained at luncheon in the board-room by the president, who proposed a vote of thanks to the directors for their courtesy in receiving the branch.

The Central Station Companion.—This instrument, which was described in our issue of August 15th, 1890, and which is a combination of testing apparatus contained in one instrument, designed by Messrs. Dowsing and Day, was shown at the Royal Institution on April 10th, and at the Civil Engineers last week. It aroused great interest from the many uses to which it could be put, and its very compact arrangement. It has recently received an addition, whereby it could be used as a potentiometer, and this will of course be most useful in central station work. We understand that Messrs. Poole and White are manufacturing the instruments, and will have them on sale very shortly.

Electric Light Treatment.—A polished funnel reflector, with a 4-volt lamp at its smaller end, is the apparatus used by M. Stanislas Stein, of Moscow, for taking away aches and pains after the fashion of the sunbath, celebrated half a century back. The reflector is applied directly to the place affected—for headache 10 seconds to 15 seconds only, for lumbago and similar nervous affections for five minutes at a time. Two illuminations of five minutes are stated to have cured a violent spasm of gout as by enchantment. This statement seems curious, to say the least, and while Mr. Lawrence is experimenting, he might like to repeat M. Stein's experiments on the next faceache or lumbago patient who applies to him.

Antwerp.—It appears, says *L'Ingénieur Conseil*, that the works for the electric lighting of the principal buildings in Antwerp will shortly be commenced. The differences that existed with the gas company have been removed by reason of certain concessions of the electric light company. It is now several years since work on a considerable scale was undertaken with the view of the erection of a central electric station, the mains being already laid in the streets, but when the Compagnie Général d'Electricité, then under the direction of M. Nothomb, wished to commence lighting, a prohibition was served upon him by the gas company, the lawsuit having dragged on for several years, and the courts finally awarded the decision to the gas company who had the monopoly of lighting in Antwerp.

Overhead Trolleys.—The overhead trolley system of electrical traction is not, so it would seem from report, by any means satisfactory; at least, in its present stage of development. Complaints come from many quarters, says the *Scientific American*, that it is insufficient and uncertain. Much snow or rain and much leakage have come to be synonymous terms in street railway parlance, and there is another class of physical phenomena, not yet understood, which so seriously impairs the driving power of the motor as to call for large parcels of additional energy from the generating station. Where this is not forthcoming, outside aid must be had to prevent interruption of service, one of the Cleveland electric railways being recently compelled to hire horses to haul their cars on uphill grades till normal conditions again prevailed.

L. C. C. and the Central London Railway.—The Parliamentary Committee of the London County Council have considered to what extent their opposition to the Central Railway Bill should be carried in the House of Lords, and having regard to the refusal of Parliament to entertain the question raised in the Council's first petition of ultimate purchase by the local authority, the committee do not think it advisable to raise the question again. They are of opinion that the opposition should be limited to the protection of the Council's general interests, and to securing the insertion of any alterations or additions which may be necessary in the clauses of the Bill as passed by the House of Commons. They recommend that a petition be presented to the House of Lords against the Central London Railway Bill, to protect the general interests of the Council in regard to sewers and other matters.

Restaurant Lighting.—A large installation has just been completed at the new restaurant of Messrs. T. Parker and Sons, St. Ann's-square, Manchester. Plain and unpretentious from without, the building is beautifully fitted up inside, and electric light fittings of silver and cut glass add very greatly to the effect. The generating plant comprises an 8-h.p. Otto gas engine of the latest type, made by Crossley Brothers, and a shunt-wound Manchester dynamo, made by Messrs. Mather and Platt, capable of driving 120 lights. There is also a battery of 53 accumulator cells, manufactured by Messrs. Johnson and Phillips under the Drake and Gorham patents, having an output of about 30 amperes. These have worked so far in a very satisfactory manner, and give no trouble whatever, even under heavy discharges. The contract has been carried out by the Manchester Edison-Swan Company, Limited, under the supervision of Mr. Frank B. Lea, acting as consulting engineer for Messrs. Parker.

Leeds.—At the Leeds County Council, on Friday, Alderman Harrison (chairman of the Parliamentary Committee) moved the following resolution: "That this Council, as the local authority for the borough of Leeds under the Electric Lighting Acts, 1882 and 1888, do hereby consent to the grant by the Board of Trade of a provisional order authorising the Yorkshire House-to-House Electricity Company, Limited, to construct and maintain electric lines and works, and to supply electricity within the borough on such terms and conditions as the Parliamentary Committee may approve." He remarked that no more important subject than this had engaged the attention of the Council for a considerable number of years. The matter had received the most careful consideration of the committee, and a unanimous vote; but it would be impossible to set forth all the details of the scheme within a short space of time, and it would be unfair to make a partial statement only. Mr. Battle seconded the resolution. Alderman Spark hoped they would have a full explanation at their next meeting. The resolution was then adopted, and the Council adjourned.

Electric Coal and Ore Loader.—This machine is the invention of Mr. E. Nicholson, of Cleveland, Ohio, and has been in operation in that city for several weeks. It is adapted for economic use in loading and unloading vessels or cars of iron ore, coal, or general merchandise, and conveying the load to any desired point. A 30-h.p. Rae electric motor is mounted upon a light tramcar holding suitable hoisting mechanism, and the operator riding upon this car hoists the load from any desired point and rapidly conveys it to the place of unloading. The constant presence of the operator over his work has a great advantage over steam automatic cable systems. The work now being performed by the plant is unloading a vessel of iron ore, hoisting a load of 3,000lb. vertically 5ft. per second, then travelling across a bridge 30ft. high and 200ft. long, spanning the ore deck, the cross travel being made in 10 seconds, and the operator stopping the car, holding the bucket and dumping the load at any desired point. This plant has been examined by prominent iron ore and coal owners and pronounced a success. A company is about to be organised to manufacture the plant for coaling terminals and general work.

Frankfort Official Journal.—By order of the board of directors of the international electrical exhibition in Frankfort, an official paper is to be published under the title of *Electricität.* It is to appear in weekly issues, and will be edited by Dr. Max Quarck and H. Massenbach, engineer, in Frankfort. It will be the mouthpiece for the official reports of all the particulars of the electro-technical exhibition. The journal will bring before its readers a history of the origin and course of the exhibition, a complete representation of the present state and prospects of electro-technics, an authentic report of the work of the juries and the consultations of the professional congresses which are to meet during the exhibition, as well as carefully-selected, reliable reports and discussions on the exhibits. The *Electricität*, *Officielle Ausstellungszeitung*, will also contain original papers, detailed reports and notices, and will be illustrated by illustrations, sketches, and plans. It will be published weekly, commencing on April 15th, and there will be altogether 30 issues, each having at least three sheets. When finished it is expected to form a worthy memorial of the present state of electrical science and of the international exhibition at Frankfort.

Utilisation of Water Power in Ireland.—The first instance of the utilisation of water power by electricity in Ireland for mill driving is at the works of Mr. Charles A. Webb, of Quartertown, near Mallow. There are three large mills—two side by side, and the third about a quarter of a mile distant—all worked by the same stream. In the first two it was found necessary to supplement the water power by steam power. Within the last 12 months the isolated mill was burned down, but the wheel and gearing escaped, and the idea of utilising the intact wheel to generate electricity by which to work the mill has been so perfected, that its success seems no longer in doubt. A large constant-current dynamo is worked by the mill wheel above mentioned. The electricity is conveyed by insulated wires to a motor in the other mills, and is there converted into a motive power to work them. The economic saving resulting from the utilisation of electricity instead of steam, is stated to amount from a ton to 25cwt. of coal per day. By means of a second dynamo machine worked by the same mill wheel, the other mills and the houses in the vicinity are lighted by electricity, and the Town Commissioners contemplate lighting Mallow by the waste electricity, if an amicable arrangement can be come to with Mr. Webb. A further scheme is contemplated to utilise the spare electricity to run a tramway between the two mills. Telephonic communication connects the isolated mill with the other two, and an electric bell is used as a signal.

Maquay's Primary Battery.—So many systems of primary batteries have been brought out that it really seems about time someone carried out all the little sets of apparatus that primary batteries are fit for, and make a speciality of it, so that if a man wanted a battery from half up to 20 candles he could go and get it. Mr. Maquay has set up business in this department at 9, Frith-street, Soho, and has quite a small exhibition of primary batteries for all sorts and sizes of lamps, many of which will no doubt be extremely useful. The fitting of these cells is ingeniously contrived for raising and lowering, and is applied to dentists', surgeons', miners', gas engineers' use, as well as for table lamps and larger installations, if need be, for house lighting. Mr. Maquay uses very small zincs, which he supplies at 4d. a dozen. These last about 16 hours, or three or four days' ordinary use. The zincs have a very particular feature, which is patented. They are covered on one side by a thin coating of paint. As the solution is used and gets warm this paint peels off gradually, and so more zinc is exposed to the action of the acid. We have been shown some curious figures of results from a miner's lamp, where 0, 3, 6, 9, 10, 12 hours' run corresponded with 3·5, 3·4, 3·6, 3·7, 3·5, 3·4 volts, the pressure rising even during the run; for a 24-cell battery during a seven hours' run, the voltage ran 29·5, 31, 34, 32, 30 volts, showing the same result. The cells are extremely small and light for the power, a battery to light one 100-volt 16-c.p. lamp even being shown in a moderate size box, 3ft. square or so. A large battery is arranged to charge and recharge itself entirely automatically, the liquid running in being controlled by a valve opened by an electromagnet, and the plates being raised out of contact in the same way when the lights are all turned off.

Birmingham Central Station.—The Birmingham central electric station was formally opened on Wednesday by the Mayor of Birmingham, Alderman Clayton, in the presence of a number of influential local gentlemen and the engineers of the company. The station, which is situated in Dale End, has been designed and superintended by Mr. J. C. Vaudrey upon similar lines to the Liverpool central station. The site allows for extensions, and at present there are three steel Lancashire boilers. The dynamo-room contains three steam dynamos, with foundations for four others. Each dynamo is capable of supplying 1,500 16-c.p. lamps, and is driven by a Willans engine at 350 revolutions, with 120lb. of steam. The current is distributed by 12 pair of feeders. In the accumulator-room a number of Crompton-Howell cells are being arranged as reservoir of energy. The underground mains are arranged on a combination of Crompton culverts under the pavement, and Callender mains in solid bitumen where the demand can be gauged or the culverts are impracticable. Chamberlain and Hookham meters are used, to be tested under the supervision of Mr. Henry Lea, official inspector to the City Council. The charge for current will be 8d. per unit. The buildings have been erected by Mr. John Webb from designs by Mr. Ewen Harper. Mains are already laid covering 6,160 yards of frontage, requiring 42,000 yards of copper strip, weighing 100 tons. The capacity of the finished station will be 10,500 16-c.p. lamps, and they started with orders for 2,367 and capacity for 4,500 lamps. The system is direct low-pressure at 110 volts, giving hardly so much shock to the hands as from a medical battery. The current was turned on by the Mayor, who stated that the Corporation were the first customers of the company in the order for the lighting of the Victoria Courts.

Wiring Slide Rule.—A really interesting little invention or adaptation has been sent to us for notice by Messrs. Crompton and Co., in the shape of a wiring slide rule for the use of electrical engineers. It is pocket size, with two fixed and two sliding scales, the object being to reduce the calculations necessary in arranging the sizes of wires and to ensure accuracy. The rule has been made in cardboard for the first thousand, but if the demand is sufficient they will be made of more durable material. It is stated to be so simple that a workman can use it, though we doubt if the ordinary workman could be safely left to manipulate a slide rule rather than to follow instructions, or to look at a distinct table of wires as is now often given. But in the hands of a superintending electrical engineer the slide rule should be extremely useful. The problems to be solved generally contain several data or known quantities and one principal answer. In using the rule, the known quantities must be taken in pairs. The scales are arranged in such pairs on the meeting edges of the slide; take, for instance, watts and volts, number of lamps and volts fall, length of cable, and size of cable. There are in general five known quantities. The divisions in the scale must be found, and one quantity must be set against the other. If the upper slide, for example, be pulled about 1¾in. to the left, 100 volts will be set against 32 watts. When two pairs are thus set, the fifth quantity must be found on one of the remaining scales, and the answer may be read off against it. Instructions for working the rule are printed on the paper envelope in which it is enclosed, and the price is half-a-crown.

Chicago World's Fair.—The great area in the Mississippi valley, of which Chicago forms the business centre, though at first it sounds an exaggeration, is four times as large as Great Britain, France, and Germany combined. Chicago has 27 different railway lines radiating like the spokes of a wheel, and within 1,000 miles' radius there is a population of 56,000,000. The railway journey from New York to Chicago, though it takes 22 hours, yet is much less formidable an undertaking, by reason of the absence of change of carriage and the luxury of the cars, than the journey between London and Paris. Passengers from New York will have opportunities of seeing some of the most interesting features of American life, and amongst other sights can visit the Niagara Falls. The park of 1,000 acres for the exhibition has a frontage of two miles on Lake Michigan, the second largest body of fresh water on the globe. Chicago is more cosmopolitan than almost any other American city, the last census giving 27 different nationalities—of the total nearly one-third were Germans, Americans and Irish coming next. There are 531 newspapers published in Chicago, and 20,000,000lb. of press matter is posted annually. During the year 500,000,000 mail packages pass through the Chicago post, weighing 27,000 tons. There are 500 churches, 25 theatres, 120 public schools, and 1,400 hotels in the metropolis of the West. Preparations are being pushed for a Congress of Thinkers in connection with the World's Fair, in which important results of modern progress will be set forth. Announcement is made of the chairmen, secretaries, and members of the general committees on the sub-congresses on education, science and philosophy, temperance, moral and social questions, labour, literature, law reform, religion, medicine and surgery, commerce and finance, agriculture, arbitration and peace, music, etc.; also chairmen of the committees of the woman's branch of the congress are given for sub-congresses on schools and teachers, household economies, social reform, temperance, charities, churches, missions, physicians, authors and journalism, art and artists, music, etc. The persons named on these committees include many men and women eminent in the various branches of learning and research. The chief of the electrical department of the World's Fair Executive Committee is Prof. John P. Barrett.

Cambridge. — At the meeting of the Cambridge Town Council, Alderman Finch spoke with reference to the resolution which was passed instructing the Electric Lighting Committee to prepare contracts for lighting Cambridge with the electric light, and submit them for the approval of the Council. The committee had proceeded to prepare contracts in accordance with the instructions they had received, and also to ascertain to what extent they should make provision. They issued a circular in order to know approximately the amount of light that would be required. The committee invited tenders for the erection of a station, and when they came to examine the tenders they found that instead of the sum being £4,900, as was put down in the report of the probable expenditure, the lowest tender was £11,260. That result surprised the committee, and it was found that whatever else was done a building on such a scale as that was out of the question. Furthermore, it occurred to the committee that there might, perhaps, be a scheme that was not quite so excessive in cost as the one recommended by Dr. Fleming, and would not be too costly for their purpose. Therefore, they appointed a sub-committee to proceed to other stations to see what buildings were sufficient, and to study some of the schemes. They first went to Newcastle and then to Bradford, and, as a result, they presented a report to the committee, which had been adopted. The report was rather too long to read on that occasion. The system they recommended was remarkable for its mechanism, and for the small amount of labour that was required. Dr. Fleming, they believed, would be unwilling to take upon himself the responsibility of carrying out a scheme which he did not recommend, and as the committee were not electrical engineers, they would like to be in a position to ask for information from an authoritative and responsible person. They had ascertained there were already persons in different parts of the town prepared to take the light to the extent of 2,700 lights. That was a very large number indeed, and he thought there was very little doubt that when the concern was established they would have 4,000 lights in the town. He proposed: "That the committee prepare the contracts they were directed to prepare with liberty, if necessary, to consult another expert." Councillor Vinter seconded. They had entered upon a new departure from the original plan, and the committee had, at least, confidence in the suggestion which was drawn up in their report. After the opinion which the professional adviser of the Corporation, Dr. Fleming, had given, it was not reasonable to suppose that he would advocate another plan, and therefore Alderman Finch's proposition to call in, if necessary, another expert was of the greatest importance in order to arrive at a right judgment on that matter. Councillor Flack thought the committee were perfectly justified in bringing about a further scheme. Councillor Bullock supported the proposition. He had every confidence in Dr. Fleming, and he hoped he would continue to act as their adviser. A discussion then took place as to the advisability of having the report of the committee read. It was eventually decided to have the report printed, and not read at that meeting. The proposition was carried by 24 votes.

CENTRAL STATION POLICY.

The numerous provisional orders for electric lighting applied for and issued by the Board of Trade during the past two years or so have been pretty well divided between public and private bodies—between, that is, corporations or other local governments, and companies, firms, or individuals.

In many cases, however, these orders have proved most decidedly to be "white elephants" to both classes; for the electrical companies or firms have found it a matter of some difficulty to adequately develop the whole of their numerous projects, while local corporations and other similar public bodies are more often than not at their wit's end to know what to do with an order that involves the possession of great technical skill at every point.

With the private firms or joint-stock companies, the questions are, how can the necessary capital be raised, and how are local prejudices to be guided? With corporations the problem becomes, Are we to do the work ourselves, or is it more advisable to pass on our order (under certain conditions and restrictions) to a private undertaking?

Under these circumstances, it may be worth while for the benefit of many to set out in plain, common-sense language the possibilities and advantages of either course so far as the corporations are concerned. As for the private undertakings, we may leave them out of consideration, since it is not our province to indicate sources of capital or methods of persuasion, so that at present the question may be considered as one solely affecting local government.

The work to be done in connection with central station electric lighting is, of course, twofold. There is, first, the *erection* of the buildings, plant, machinery, etc.; and second, the *maintenance* thereof, or, in other words, the *supply*.

How far is it advisable for a municipal body, a corporation, or local board, or whatever it may be, to undertake both these schemes of work in connection with electric light and power?

With regard to the first point, the unhesitating answer of anyone would be decidedly in the negative. Corporations may be well able to install, if not actually manufacture, such things as gas and water pipes, or to undertake sewering contracts on a small scale, but no sensible being would maintain for a moment that a large public central station for the supply of electric energy could be better or more cheaply installed by a corporation or municipal body than by an established firm or company of skilled electrical engineers whose whole time is spent in devising the best means and methods, and whose experience alone is thoroughly worth the bare trade profit that is allowed by keen competition in this class of work.

Central stations, then, will certainly be erected throughout by contractors who may or may not have anything to do with the subsequent supply of current; and it is not in the remotest degree likely that any corporation will undertake the work itself. The trouble involved thereby, as well as the high payments necessary for skilled advice at every step, would far more than balance the profit of an outside contractor undertaking the work.

Turning now to the second question—viz., that concerning the supply of energy from a station when erected and in full working order—the answer to be given will depend on the relative importance that must attach to the interests respectively of shareholders in a firm or limited company, and of the general body of ratepayers in the lighted district.

If every other consideration must give way in the opinion of local authorities to the interests of a ratepaying public, then it may be said without hesitation that under the Electric Lighting Acts as at present enforced municipalities cannot do better than allow private enterprise to compete for the privilege of *supplying* electric energy to the public, as well as of contracting for the erection of necessary plant. The conditions are very different to those that prevailed when gas companies originated, and private enterprise is tied down to a maximum period of 42 years in which to work up a profitable business. No perpetual and absolute monopoly of lighting is permissible, and at the end of the term above named, or of such shorter term as the local authority may insist upon, the whole enterprise can be taken over by the municipality at a fair price without consideration of goodwill in any shape. As a matter of business, therefore, it would appear evident that local authorities will consult their own interests best by posing as the monkey in the fable, and using private enterprise as the cat to pull chestnuts out of the fire. If this is the case, it may be asked why are the directors of private companies so foolish as to take up the public supply of electric energy on such terms? The answer, of course, is that the directors consider they will obtain a fair interest for their capital during the term of supply, in spite of the disadvantages attending the initial stages of every such scheme. Probably—nay, certainly, they *can* earn sufficient dividends for the satisfaction of their capital, but it is done by the use of the highest technical skill and continuous supervision in every detail.

The same results could not be achieved in the present state of the electrical industry by any local authority, inasmuch as a skilled staff would be necessary in each case, and considerable experience would be bought before the station began to prove at all remunerative. That is, speaking from the standpoint of a corporation, one would say, by all means allow a private undertaking to bear the responsibility and drudgery of the work in its earliest stages. At the end of so many years, the corporation can take over the whole affair on most favourable terms as regards the public interest; and if, in the meantime, further important discoveries should be made in the science of electric lighting, either in connection with generating or applying the electric energy, the corporation would then be in a better position to take up such improvements than if the ratepayers' money had been invested in apparatus as at present used.

In 21 or 42 years it is more than likely that considerable improvements will be made in the methods now employed; it may even be possible that someone shall devise a means of obtaining light without heat, and that instead of the proportion now existing of, say, 90 per cent. heat to 10 per cent. of light, we shall have these figures completely reversed.

Whether the shareholders in any private undertaking will duly appreciate the position thus assumed to be taken by corporations or other local authorities, may be doubtful in the extreme; but those who know best and can speak from long experience give it as their "dictum" that such shareholders need not fear the want of adequate returns upon their capital invested. Provided that due skill be employed, and proper management secured, the public supply of electric energy can be made to pay, and pay well—even on the somewhat onerous conditions laid down by local authorities under the powers they possess. But it may be said, with almost perfect confidence, that, based on the results to be seen in other directions, a public body would not, in its early stages at least, administer such a scheme so economically and efficiently as would the board of directors in a private undertaking, whose interests are in every way most closely bound up with the success of the scheme.

Should, however, any corporation or local governing body be found so venturesome as to take the question of immediate supply into its own hands, or should any of its members or committees be so fortunately placed as to have at command the best technical skill, then, doubtless, all the above well-meant advice would be thrown away, or be useless.

If a local authority is bent upon undertaking the work, let it, in the name of common-sense, secure such skilled advice as may be honestly called "independent" and unbiassed. There are not by any means too many consulting electrical engineers, properly so called; the industry is calling for more, but they are to be perfectly independent and unconnected with any firm or company of manufacturers. How can a corporation safely consult Mr. So-and-So as to the relative advantages of high and low tensions for the town in question, when it is a matter of common knowledge that he is an inventor of dynamos, and draws a royalty from several firms who make them? What right have public officials or professors at our universities and other teaching centres to pose as consulting engineers, even in their spare time? They should be paid more highly, if necessary, so that their leisure may be spent in developing and ripening the work they undertake as a means of livelihood. It is impossible for those who are in the position of educators at our teaching centres to keep in close touch with the practical working and actual experience that alone enable a consulting engineer to cope with all contingencies.

The number of absolutely independent engineers who may be consulted by a public body in search of advice and guidance on electric questions is, to say the least of it, somewhat microscopical; whether any exist at all may even be questioned. There is in this no calling into account the *bona fides* of those practising at present; their standing is sufficient to ensure straightforward advice; but Cæsar's wife must be above suspicion, and the official-professorial-manufacturing-consulting engineer will have to give way to others whose independence is absolute, and whose names are received with the highest respect by all members of the same industry.

TRANSMISSION OF POWER BY ROTARY-PHASE ALTERNATE CURRENTS.*

BY M. VON DOLIVO-DOBROWOLSKY.

(Continued from page 370.)

The practical application of the transmission of three currents, displaced in their phase by 60deg. as regards one another, has its main impediment in the necessary increase in the number of conductors. If determined by a better utilisation of the dynamo (which will be later discussed), and by the possibility of long-distance transmission, we proceed, like Tesla, transmitting two currents by three conductors, and, we assume, four conductors for transmitting three currents, these four conductors would still be too expensive. A simple commutation, however, allows the transmission of three currents by means of three conductors, and, in fact, with a still less expenditure of material than two Ferraris-Tesla currents with three conductors would require. This can be effected in employing three currents differing in their phase by 120deg. instead of 60deg., and in reversing the connection of the generator coils supplying the one current (II. in Fig. 4). As each circuit in the motor corresponds at least to two oppositely wound coils producing one north and one south pole, we may in relation to their action consider the absolute values of the currents, and add to each current its opposite one (see Fig. 5). Thus Fig. 3 is transformed to Fig. 5. This figure represents the mode of operation of three currents differing by 120deg., which is perfectly analogous to that represented in Fig. 3 for three currents differing by 60deg.

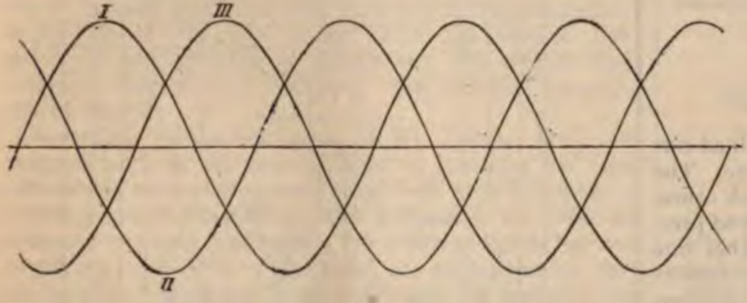

Fig. 4.

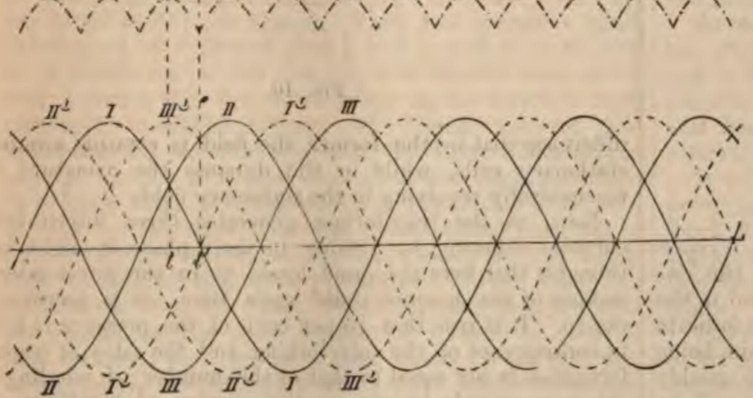

Fig. 5

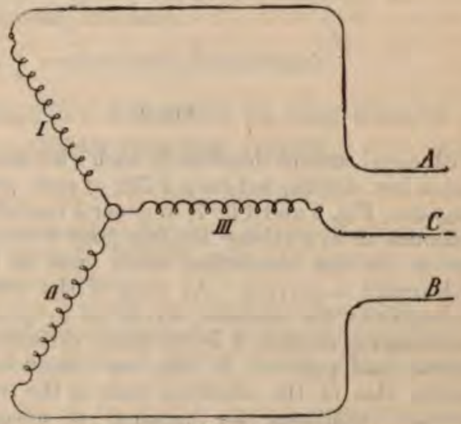

Fig. 6.

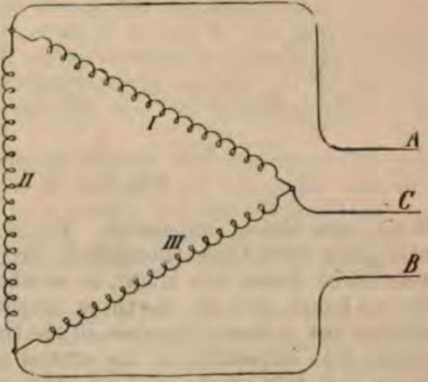

Fig. 7.

In considering Fig. 5, we see that at the time *t* the sum of the currents I. and II. is = 2 sin 30deg. × *i* max, while current III. is = *i* max; hence I. + II. = III., as sin 30deg. = 0·5deg. On the other hand, at the instant *t'*, I. is = 0, II. = sin 60deg., and III. = sin 120deg.; therefore, again, I. + II. = III. This relation holds good in general from moment to moment, as may be easily proved for sinoidal currents. Each of the currents, or pressures, is equal and opposite to the sum of the other two; their algebraical sum is always = 0, while the sum of the absolute values, as shown above, is fluctuating between 2 *i* and 1·732 *i*. From the fact that at every instant the algebraic sum of the three currents, or pressures, is = 0, it follows by Kirchhoff's law that one of the currents may be connected in series or in parallel with the sum of the two other. Thus we receive two modes of connection diagrammatically represented in Fig. 6 and Fig. 7. In Fig. 6 the current I. is always in series with the parallel currents II. and III.; likewise II. with I. and III., and, finally, III. with I. and II. In Fig. 7, on the contrary, the pressure of I. is equal to the pressure of (II. + III.), II. = (I. + III.), and III. = (I. + II.), and accordingly we may connect the current I. in parallel with the currents II. and III. joined up in series, etc. The first connection we call the "open," and the latter one the "closed" interlinking of the currents. This interlinking renders possible the long-distance transmission of three currents by means of three conductors, as the current flowing in the one conductor finds its return way in the two others. The same methods of connection may be applied also, of course, to more than three conductors. This interlinking of the currents has been contemporaneously and independently invented by Bradley, Wenström, Haselwander, and the present writer. In the course of copious trials made by the latter in the Allgemeine Company and during his working out the system, there appeared many important reasons which induced the writer to deviate from this simple arrangement; among these reasons are to be pointed out the smaller output eventually occurring in the current interlinking, hence the low efficiency and the high price of dynamos and motors, the difficulty of regulation and measurement of the three interlinked circuits, the increased difficulty of control, etc.

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* Translated from the *Electrotechnische Zeitschrift*.

The fact that interlinked currents disturb each other not unessentially is explained as follows: In considering Fig. 6 we see that the current flowing through the conductors A and B is produced by the sum of the E.M.F.'s of I. and II., yet in consequence of connecting together the maxima of these two pressures appear not contemporaneously, but at a distance of 60deg., and, therefore, the pressure from A to B is less than the sum of the two pressures I. and II.; it amounts only to 21 in 60deg. + *e*—*i.e.*, 1·732 *e* instead of 2 *e*. Therefore, the resulting average pressure relates also to the sum of the single average pressures as 1·732:2. Consequently, if we want to obtain a definite pressure in the leads, the machine must receive $\frac{2}{1{\cdot}732}$ times more windings than if the currents were separately added together. In the case of currents not quite sinoidal these relations are still more considerable, and they often reduce the efficiency of the machine. We have the same thing in the interlinking represented by Fig. 7. Though I., II., and III. are connected in parallel, they supply still unequal currents.

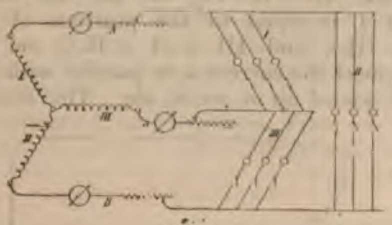

FIG. 8.

With equal current densities in each wire the combined current is not double, but only 1·732 of each single one. The diagrams, Fig. 6 and Fig. 7, in general resemble each other, inasmuch as everything holding good with regard to pressure in the one connection holds good in the other one with regard to current. As each of the three conductors leading from the machine serves, so to speak, for the two neighbouring circuits, it is extremely difficult on measuring current and pressure in the one conductor to form a precise idea of the electrical state in the two others; the pressure regulation, for instance, at unequal loads, by means of induction coils inserted in the circuit, is very difficult, even almost impossible. Fig. 8 and Fig. 9 represent a plant with three interlinked circuits; in the one circuit three lamps are alight, in another one, and in the third no lamps, yet all the three ampere-meters indicate currents; the current impulses in the three circuits being unequal, it is impossible at the central station to quickly observe the distribution of load; the regulation will be often effected in the wrong direction, there being no time to see the right way in the complicated interlinking of currents. Each variation in the one conductor affects the others; if we insert, for instance, an induction coil in B, the pressure in the circuit III. being a little risen on account of less load, the pressure in II. sinks contrary to our intention, and with each attempt of correcting it we may produce a change in the pressures of the two others. The regulation becomes almost a thing of impossibility. Of course, in an exclusive electromotor service, no unequal loading occurs, still we must have regard also to loading by lamps.

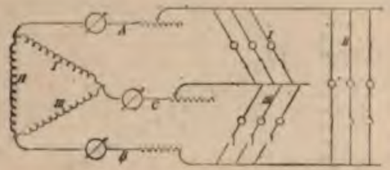

FIG. 9.

These were the alleged reasons—deterioration of primary as well as secondary machines, and the difficulties of regulation and measurement—which induced the present writer to abandon the simple mode of rotary current interlinking indicated, and to work out the following system now generally employed by the Allgemeine Company. The dynamos supply several quite independent currents, as a rule, though the number may be chosen at will. A high number of currents allows an efficient use of the dynamo, as the entire periphery of the armature can be covered with active windings, which cannot be done in ordinary alternate-current dynamos. The better efficiency is quite evident from the fact that, by a multiple-phase or rotary-current dynamo, electrical energy is supplied continually, while by an ordinary alternate-current machine only in pulsations. So, also, the flow of rotary-current energy in the conductors is constant, the arithmetical sum of the single currents, as we proved, being practically constant, perfectly analogous to a continuous current. The single currents supplied by the machine are separately carried through switches, regulating inductors, and measuring instruments, and then they are united, by means of suitable transformers, to three interlinked currents differing by 120deg. in their phase; these three currents are transmitted to the required distant place, where they are eventually split up according to the use required. The transformers employed, patented by the Allgemeine Company, are based on the rotation of a magnetic field within closed, poleless iron masses, by the action of the complex current coming from the machine and producing similar successive current impulses in the secondary windings. The operation of the transformer corresponds to that of a rotary-current dynamo, with the difference that in the former the field is rotating around stationary coils, while in the dynamo the armature is mechanically revolving in the stationary field.

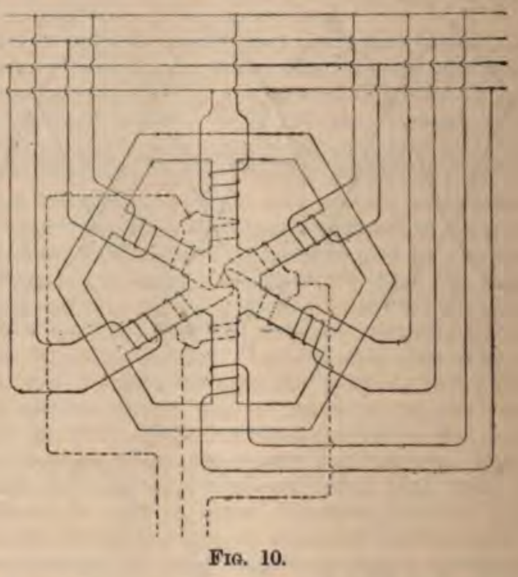

FIG. 10.

Now, as the transformer generates three interlinked currents differing by 120deg. in their phase, it might be thought that here the same losses as in the direct interlinking of the currents could again arise. It is, however, not so. It is true that 15 per cent. of the pressure is lost in consequence of the interlinking and the ratio of transformation is not equal to that of the number of windings, yet we want only to increase the number of windings of the secondary interlinked currents by 15 per cent. in order to make a full use of the primary currents. The efficiency of the transformer is thereby only inconsiderably affected. In general, the loss of transformation and the cost of the transformers themselves can scarcely be taken into consideration, as at present it is generally preferred to build machines of a relatively low voltage, and to transform the energy up to a high pressure for long-distance transmission. The cheapness and safety of a dynamo for 50 to 100 volts will compensate for the cost of a transformer, and a low-pressure dynamo works with so much greater economy as to counterbalance the loss by transformation of even 3 or 4 per cent. We scarcely need to point out that in the case of very high-pressure currents—perhaps over 10,000 volts—this method is, in general, the only applicable one.

Fig. 10 shows diagrammatically one of the many possible arrangements of a rotary-current transformer transforming the six single primary currents to three interlinked currents. The phenomena in the interlinked circuits of secondary coils are clearly traceable in the single primary circuits, so that the regulation of currents and pressures is quite simple and distinct. Moreover, we have in the interlinking of the secondary currents the advantage in the expensive long-distance transmission of needing only three conductors instead of four. At the place of utilisation it is advisable, where the current is to be used for driving larger motors as well as for lighting purposes, to arrange the second transformation so as to employ the interlinked currents separately again, for reasons we have indicated with regard to the dynamos.

We shall see, subsequently, that the weight of three rotary-current conductors transmitting a given energy is not greater than the weight of two conductors otherwise employed for the same purpose.

(To be continued.)

CHATHAM CENTRAL ELECTRIC STATION AND THE SOUTH-EASTERN RAILWAY.

The Chatham Electric Light Company have just been joining issue with the South-Eastern Railway Company upon the question of the amount of compensation which should be paid by the railway company for the compulsory acquisition of the land upon which the electric light station is now situated at Rochester. The electric light company claimed £11,000, and the railway company offered £5,000.

According to the statement of Mr. Bidder, Q.C., the progress made by the electric lighting company had been remarkably encouraging, and it had been very fortunate in securing a suitable site for the business. In 1889 the company was only supplying a few hundred lights, but now supplying over 3,000. The plant was expensive, but they contemplated increasing it, and although the profit for the last quarter only showed £75, as the company were constantly receiving fresh applications for lights, there was no doubt that the time was coming when the shareholders would secure an ample return for their capital. The electric light company held a lease of their premises at the Victualling Office Wharf, Rochester, at the low rental of £55 per annum. They had erected a plant at a cost of £7,500, and sunk a well at a cost of £1,400, all of which the railway company had allowed them to do, well knowing that they were doing so, for they had been written to upon the subject. His clients, however, had found another suitable site near the River Medway, the price of which was £1,500, but there was work necessary to be done which would involve a certain outlay of £5,000, so that by the time they had re-established their works they would have expended in round figures £7,500, which they considered the railway company should pay. In addition to that, his clients would forfeit a rental of £55 per annum for 12½ years certain for a rental of £350 if they reckoned at 5 per cent. their outlay on the new premises, and, in addition, they would have heavy rates and taxes to pay. Therefore it was fair that his clients should be compensated for the extra annual cost, and also that they should not be turned out of their premises until they were prepared to supply their customers from their new premises. Mr. F. Wingent, a director of the electric light company, made a similar statement to the counsel, and pointed out that, although there might be no stoppage in the supply of light, the removal would be a certain and substantial element of damage, as it would arrest the development of the business of his company through the delay in putting up a duplicate plant. Mr. Albert Maine, manager of the electric light company, said they possessed a 200-h.p. horizontal condensing engine, a tubular boiler, rated at 125 h.p., and one of the best forms of dynamos, which was capable of producing another 500 8-c.p. lights, if the engine was equal to it. They had been singularly free from stoppages, as they had only one stoppage of an hour last year. Mr. G. Pepper, secretary to the electric light company, produced the accounts and said an increase of customers now would mean a very little increase in expenditure. Mr. Ferranti, electrical engineer, of Charterhouse-square, London, said he was consulting engineer to the Chatham Electric Lighting Company, and said that with a trifling expenditure on the present site (£50 per annum) the company could earn £200 or £300 per year more. The expenses would not be much increased by the duplication, but the lights would be more than doubled. He considered the business was now being arrested at a critical stage. The value of the plant on the present site which could be removed by the company, would not be more than £2,500. The price of the light varied from 3¾d. for the Board of Trade unit up to 4½d., which was lower than that charged by any other company that he knew of. Dr. J. Hopkinson, F.R.S., past president of the Institution of Electrical Engineers, and Prof. Henry Robinson, M.I.C.E., concurred with Mr. Ferranti. The Solicitor-General (Sir Edward Clarke), on behalf of the railway company, agreed to give undisturbed possession of a portion of the land for a year. Mr. Robert Viger, surveyor, calculated it would cost the electric company £3,325 to reinstate themselves on a new site, for interference with business, and other contingencies. He fixed the total compensation which should be given at £11,142. The Solicitor-General said the railway company considered £5,000 ample compensation, and called witnesses as to the value of the site. In the end the enquiry, after lasting several days, terminated in an award of £7,000 for the electric lighting company.

THE HIGHEST ECONOMY IN THE USE OF INCANDESCENT LAMPS.

BY H. WARD LEONARD.

In operating incandescent lamps of any particular make, their average life will depend upon the incandescence at which they are operated.

The higher the incandescence of the carbon filament, the greater the amount of light which will be produced by the expenditure of a certain amount of energy, and the less the average life.

Lamps can be made by any manufacturer which shall have practically any desired average life, if the efficiency be not fixed.

As we decrease the power necessary—that is, increase the efficiency—we effect a saving in the first investment and in the cost of power required to operate the lamps, but simultaneously we decrease the average life of the lamps, and hence increase the cost in operating due to lamp renewals.

It will therefore be evident that whenever the cost of power and the cost of incandescent lamps for renewals is fixed, there will be a certain definite efficiency and corresponding life, which for any particular make of lamp will represent the condition of highest economy in the use of the lamps.

The consumer of incandescent lamps has forcibly brought to his attention the cost of the lamps he uses for renewals, but is usually unable to determine definitely the amount and value of the power required to operate the lamps. Consequently, he is frequently led to believe that the cheapest lamp for him to use is necessarily that which gives the longest life. Unless the power required is the same for the different lamps, this is not true, and frequently consumers are operating at very poor economy, and yet believe they are obtaining very good results, merely because their lamp breakage is small.

Let us examine this subject briefly.

The measurement of light is rated in "candle-power," and the efficiency of production of the light is rated in "watts per candle."

The number of watts required by any lamp is the product of the volts and amperes used by the lamp.

Thus a 100-volt lamp using half an ampere absorbs 50 watts, and if the lamp be a 16-c.p. lamp, the "watts per candle," which is the measure of its efficiency, would be $\frac{50}{16} = 3{\cdot}1$ watts per candle.

Similarly, a lamp of 24 c.p. taking 110 volts and ·676 ampere absorbs 75 watts, and has an efficiency, as before, of $\frac{76}{24} = 3{\cdot}1$ watts per candle.

These two lamps, operated as indicated above, will have the same average life, because the incandescence of the carbon, and therefore the efficiency, is the same in the two instances. Let us suppose this average life to be 600 hours with the efficiency mentioned—namely, 3·1 watts per candle.

Now, suppose we take the lamp designed to be operated at 3·1 watts per candle, giving 24 c.p. at 110 volts, and instead of subjecting it to 110 volts, reduce the pressure to 104 volts. The reduction of pressure will cause a reduction in the current through the lamp from ·676 ampere to ·623 ampere; consequently, the watts absorbed by the filament will be 104 × ·623 = 65 watts. The candle-power will be found to be 16 instead of 24, as formerly. The efficiency will be $\frac{65}{16} = 4{\cdot}06$ watts per candle. The average life at this efficiency will be not less than 1,500 hours.

Yet it does not follow that the most economical results will be obtained by operating the lamps at such an efficiency and life, although at first such might be thought to be the case.

In order to investigate this question, it becomes necessary to determine the cost of power under different conditions. Perhaps the best authority on this subject is Charles E. Emery, Ph.D., who has thoroughly investigated and reported upon this question. The following values are taken from his report.

The cost of producing 1 h.p. for 10 hours per day for 309 days in the year, by means of a first-class engine using 27lb. of feed-water per indicated horse-power per hour, is 52.15dols., where anthracite coal is 4.17dols. per ton, and where an engineer's wages are 2dols. per day. Of this 52.15dols., 24.06dols. is the cost of the coal, and 28.09dols. is that due to expenses outside of coal, such as wages, repairs, oil, waste, insurance, taxes, etc. That is, it costs 52.15dols. to produce 309 × 10 = 3,090 horse-power hours, hence one horse-power hour costs $\frac{52.15}{3{,}090} = 1{\cdot}7$ cents.

The cost of the power for operating a 16-c.p. incandescent lamp will, of course, vary with the number operated per horse-power. When the lamps have an efficiency of 3·1 watts per candle, 12 16-c.p. lamps are operated for each horse-power in the driving belt of the dynamo.

When the lamps have an efficiency of 3·6 watts per candle, 10 16-c.p. lamps are operated per horse-power; with lamps of four watts per candle, nine 16-c.p. lamps are similarly operated per horse-power, and with 2·77 watts per candle 13·4 16-c.p. lamps. Consequently the cost of the power will be as follows for operating one 16-c.p. lamp for one hour:

—	For lamps of 2·77 watts per candle—*i.e.*, 13·4 lamps to h.p.	For lamps of 3·1 watts per candle—*i.e.*, 12 to h.p.	For lamps of 3·6 watts per candle—*i.e.*, 10 to h.p.	For lamps of 4 watts per candle—*i.e.*, 9 to h.p.
	Cents.	Cents.	Cents.	Cents.
Cost of power per 16-c.p. lamp-hour, with power at 1·7 cents per horse-power hour	0·129	0·14	0·17	0·19

If the average life of the lamps of 3·1 watts be 600 hours, that of the 3·6 watt lamp will be about 900 hours, that of the four-watt lamp 1,500 hours, and that of the 2·77 watt lamp 300 hours.

Let us assume that the initial cost of a 16-c.p. lamp is 44 cents, then the cost of renewals per lamp-hour would be:

—	For lamps of 2·77 watts per candle—*i.e.*, 13·4 16-c p. lamps to h.p., and 300 hours average life.	For lamps of 3·1 watts per candle—*i.e.*, 12 to h.p., and 600 hour life.	For lamps of 3·6 watts per candle—*i.e.*, 10 to h.p., and 900 hour life.	For lamps of 4 watts per candle—*i.e.*, 9 to h.p., and 1,500 hour life.
	Cents.	Cents.	Cents.	Cents.
Cost of lamp renewals per 16 c.p. lamp-hour, with lamps at 44 cents each...	0·146	0·073	0·049	0·029

Hence, the combined cost of both power and lamp renewals would be as follows:

—	For 16-c.p. lamps of 2·77 watts per candle and 300 hours average life.	For 16-c.p. lamps of 3·1 watts per candle and 600 hours average life.	For 16-c.p. lamps of 3·6 watts per candle and 900 hours average life.	For 16-c.p. lamps of 4 watts per candle and 1,500 hours average life.
	Cents.	Cents.	Cents.	Cents.
Power	·129	·140	·170	·190
Lamp renewals	·146	·073	·049	·029
Total cost per 16-c.p. lamp-hour when power costs 1·7 cents per horse-power hour and incandescent lamps cost 44 cents each	0·275	0·213	0·219	0·219

Thus, under the conditions given, the most economical lamps to use will be those of 3·1 watts per candle and 600 hours average life.

Now, let us suppose that the cost of power varies, as it will in different locations and under different conditions. It will be noted that of the 52.15dols. per year for the production of 1 h.p., 28.09dols., or 54 per cent., is independent of the cost of fuel. Let us suppose that the cost of fuel is nothing, and that the only expenses in the production of power are those due to labour, repairs, insurance, taxes, etc.

—	For 16-c.p. lamps of 2·77 watts per candle and 300 hours average life.	For 16-c.p. lamps of 3·1 watts per candle and 600 hours average life.	For 16-c.p. lamps of 3·6 watts per candle and 900 hours average life.	For 16-c.p. lamps of 4 watts per candle and 1,500 hours average life.
	Cents.	Cents.	Cents.	Cents.
Power...... ...	0·0684	0·0742	0·0901	0·1007
Lamp renewals	0·1460	0·0730	0·0490	0·0290
Total cost per 16-c.p. lamp-hour when fuel costs nothing and incandescent lamps cost 44 cents each	0·2144	0·1472	0·1391	0·1297

It will be seen that the four-watt lamp of 1,500 hours average life becomes the most economical to operate under such conditions.

Now suppose the price of anthracite coal, or its equivalent, to be 2dols. per ton. We then have the following relations:

—	For 16-c.p. lamps of 2·77 watts per candle and 300 hours average life.	For 16-c.p. lamps of 3·1 watts per candle and 600 hours average life.	For 16-c.p. lamps of 3·6 watts per candle and 900 hours average life.	For 16-c.p. lamps of 4 watts per candle and 1,500 hours average life.
	Cents.	Cents.	Cents.	Cents.
Power	0·0991	0·108	0·129	0·146
Lamp renewals	0·146	0·073	0·049	0·029
Total cost per 16-c.p. lamp-hour where anthracite coal, or its equivalent costs 2 dols. per ton, and 16-c.p. lamps cost 44 cents each.	0·245	0·181	0·178	0·175

From the above figures it will be seen that the four-watt lamp is the cheapest to operate under the conditions given, but the advantage is so trifling that in practice the 3·1 watt lamp would be the best to use, since the lamps fall off in candle-power somewhat in long use, and with lamps having an average life of 600 hours the average condition of the total number of lamps on a plant would be that due to 300 hours of burning, whereas the average condition of lamps having an average life of 1,500 hours would be that due to 750 hours' use, and it is evident that it will be preferable to have lamps which have averaged 300 hours of use rather than lamps which have averaged 750 hours of use.

It will be seen by the figures given that the life alone is a poor measure of the economy of incandescent lamp, and that in order that a four-watt lamp should equal in quality a 3·1 watt lamp its life should be 2½ times as long, and that its average candle-power in burning its 1,500 hours should equal the average candle-power of the 3·1 watt lamp in burning its 600 hours.

In all instances quoted thus far we have assumed a cost of power based upon its production for 10 hours per day under extremely favourable conditions. In the case of incandescent lighting plants the load changes widely, and the maximum load is on for only two or three hours. The production of power is much more expensive under such conditions than when the load is constant. Statistics from a very large number of central station incandescent lighting plants, charging an average rate of one cent per 16-candle lamp-hour, show that the total cost of power for operating a 16-c.p. 3·1 watt lamp is 0·4 cents per hour. The relative economy in the use of lamps of different efficiencies under average conditions of central station practice is, therefore, shown by the following table:

—	For 16-c.p. lamps of 2·77 watts per candle and 300 hours average life.	For 16-c.p. lamps of 3·1 watts per candle and 600 hours average life.	For 16-c.p. lamps of 3·6 watts per candle and 900 hours average life.	For 16-c.p. lamps of 4 watts per candle and 1,500 hours average life.
	Cents.	Cents.	Cents.	Cents.
Power	0·357	0·400	0·464	0·516
Lamp renewals	0·146	0·073	0·049	0·029
Total cost per 16-candle lamp-hour when the power to run a 16-c.p. 3·1 watt lamp cost 0·4 cents per hour, and lamps cost 44 cents each	0·503	0·473	0·513	0·545

It will be noticed that the operating expenses are 8 per cent. less in the case of a plant using 3·1 watt 600 hour lamps than in the case of a plant using 3·6 watt 900 hour lamps. This is equivalent to an increase in the net profits of 12 per cent. in the case of an incandescent electric lighting company whose expenses are 60 per cent. of the total receipts, which is an average relation between the expenses and receipts in properly operated stations.

Attention is called to the fact that if the life of the incandescent lamp be increased, or the price of the lamp be reduced, the importance of using the high-efficiency lamp rather than the low-efficiency lamp becomes even more marked than in the present instance.

Thus, if the average life of a 16-c.p. lamp of 3·1 watts be 1,200 hours, and the cost of the lamp be 40 cents, it will be found that higher economy will result by operating the lamp at 2·77 watts per candle, which will reduce the life to 600 hours. This is shown by the following table:

—	For 16-c.p. lamp of 2·77 watts per candle and 600 hours average life.	For 16-c.p. lamp of 3·1 watts per candle and 1,200 hours life.
	Cents.	Cents.
Power	0·357	0·400
Lamp renewals......... ...	0·066	0·033
Total cost per 16-c.p. lamp-hour when power for 3·1 watt lamp costs 0·4 cents per hour, and lamps cost 40 cents each.	0·423	0·433

In all systems having a fairly good regulation and distribution of pressure, and where coal costs from 2dols. upward for the equivalent of one ton of anthracite coal, the 3·1 watt lamp is the most economical.

In alternating systems as ordinarily installed the variation of pressure is often too great to use the 3·1 watt lamp economically, and the 3·6 watt lamp should be used; also in cases when the cost of power is extremely low the 3·6 watt lamp should be used. It will not be found economical to operate the best makes of lamps at more than 3·6 watts per candle under any conditions met with in practice.

The majority of 16-c.p. incandescent lamps on the market to-day require from 57 to 65 watts—that is, to have an efficiency of from 3·6 to 4 watts; and attention is called to the fact that in order to compare in quality with a lamp of 50 watts with a guaranteed average life of 600 hours, there should be a guarantee of 900 hours average life for the 57-watt lamps, and of 1,400 hours average lite for the 65-watt lamps, and that even then the consumer will not be operating at the highest economy as shown above. Furthermore, it must be borne in mind that by the use of 3·1 watt lamps, the capacity of a plant already using 3·6 watt lamps will be increased 16 per cent., and in the case of a plant using four-watt lamps, the capacity will be increased 30 per cent.

To express this another way, it may be said that a consumer having a plant using lamps of 3·1 watts, and changing to lamps of four watts, not only suffers the disadvantage due to the fact that he is not operating at the highest economy, but he also immediately increases his investment, interest, depreciation, etc., per unit of light obtained to the extent of 30 per cent., and subjects his dynamo to an overload of 30 per cent., with consequently greatly increased trouble and expense due entirely to the use of the low economy lamps, but frequently attributed to a defect in the dynamo as it is there that the overload manifests itself.

Electro-plating the Dead.—A translation of an article by M. Edant upon the process of Dr. Variot, of Paris, of electro-plating dead bodies is given, with illustration of the apparatus in action, in the *Scientific American* for April 11. The body is rendered conductive by a spray of nitrate of silver and plated to the thickness of ½ to ¾ millimetre on the face and hands, and 1 to 1½ millimetres on the other parts of the body. The process is not expected to be used instead of embalming previous to depositing in the cemetery, but rather as giving medical museums and laboratories very exact specimens of bodily contour in disease for careful comparison.

THE

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EDUCATION.

The technical journals may be permitted now and again to ignore technical subjects and touch upon other topics. Education is a subject that appeals to all, and is ever presenting itself in its different phases. Now it is what constitutes a liberal education, at another time what is the best preparation for technical work, and again what best for professional work. Many years ago, before the now defunct Social Science Congress, and also before the British Association, it was suggested that the then proposed system of School Boards was not comprehensive enough, and still left it to individual philanthropists to provide for such pupils as showed genius while in the elementary school. A pupil in an elementary school who shows greater powers than his mates, cannot look forward as to a right to enter some higher school wherein his powers may be developed for the good of the community, or on further trial found to be wanting. Here and there scholarships are given, but these are generally, as we say, the gift of individuals, and if State aid is recognised as requisite at all, it should be recognised as having the duty of providing the way to develop superior abilities. Our system is now to pay the master to bring the boys up to a certain dead level standard. Neither master nor boy has any incentive to do more than attain this standard. The hope of the greater number of boys in elementary schools is to become artizans. Technical schools and colleges are increasing in number, and are supposed to provide the requisite technical training. We opine they usually aim at too high a standard, but assuming that this is not the case—and the standard might easily be altered to what is required—would it be impossible while the question of education is being reconsidered, as politicians hint it must be, to endow technical schools in every large town, wherein boys showing talent in the elementary school might serve a kind of preliminary apprenticeship in technics—one part of the day learning to use their hands, the other part learning the why and the wherefore of such procedure. We talk about "eight hours' work, eight hours' play, eight hours' sleep, and eight bob a day," but this is only for the full-grown man. The youth, who wants play as well as work, is kept at the grindstone all day, and usually best part of the night also. He is apprenticed, or gets a berth in the shops, and after his day's work has to trot off to his science class, and after his lecture to write up his notes or read his books. There is no time for physical development, and this studious lot of young England is physically different from the other part of the race, which ignores information, and thinks only of the pleasures of the moment. Is there no means of devising a workable scheme to avoid the evils we have barely indicated, evils which are growing, and which are tending to the physical deterioration of those who should be our ablest workmen. As we have said, our technical schools aim too high. They think not of the wants of the million—they think only of the glory of turning out a man who shall make a name before a small section of his fellow-men.

INCANDESCENT LAMPS.

The paper of Mr. H. Ward Leonard, which we give elsewhere from advance proofs sent by the author, appeals not only to users, but also to the manufacturers and to supply companies. The conclusions deduced are in accord with experience. Gradually the true principles underlying the economical use of electricity are being solved, and from investigations like this of Mr. Leonard it is gradually dawning upon the minds of most people that efficiency and economy do not always mean the same thing. Again, when applied to lamps, "life" alone does not spell economy. Mr. Leonard, however, in this paper does not seem to sufficiently consider the effect of lamp deterioration, although he might possibly have made it a strong point in favour of his argument. He says: "It will be seen that the four-watt lamp is the cheapest to operate under the conditions given; but the advantage is so trifling that in practice the 3·1 watt lamp would be the best to use, since the lamps fall off in candle-power somewhat in long use," etc. What we want to know in this connection is the rate of deterioration of the various lamps. That is, does the four-watt lamp deteriorate faster, or at the same rate, or less than the 3·1 watt lamp. It is rumoured that the Edison-Swan Company, on this side the Atlantic, is keeping back an improved lamp against the time when the present patents expire. We know also that others are preparing to put lamps upon the market which they claim to be improvements upon the existing ones. Are these lamps economical?

ROTARY CURRENTS.

The *Bulletin Internationale* has a nasty little hit at the inventors of the rotary-current motors which is not deserved. "In reality," it says, "the current employed is alternating, the motor presents no new principle whatever, and the experiments only owe their celebrity to the mystery with which they have been surrounded, and the scenic effects with which they have been flourished forth." We think it may be well to set forth in plain words for those who are likely to be misled or are hazy in their ideas what the rotary current means. The rotary current is an alternating current, but it is something more: it is three alternating currents so generated, in the first place, in the dynamo, and so received, in the second place, in the motor that three phases succeed and interlink with each other (when passed through coils upon an iron ring in the motor), as to form in this iron ring a semblance of a rapidly rotating magnet. That is to say, though the iron is stationary, the wave of magnetic action in the iron rotates, and this causes an effect as if a magnet were rotating. A closed-circuit armature in such a rotating field will be dragged round until it is in step with the generating dynamo. It certainly cannot be truly said that this is nothing but an alternating current, and that the motor presents no new principle. In one sense, indeed—that the principle of alternating-current motors was discovered in 1888 by Ferraris and Tesla—it is not new, if by new is meant absolutely unfounded upon anything else known before this present year. But in the sense used, the rotary-phase alternating current is a new and a most important invention in that it brings a direct answer to the demand for a powerful and efficient alternate-current motor, and apparently solves the problem of long-distance transmission. It also, at one stroke, promises to solve the great problem of the construction of an electric motor having a solid armature and without commutator. Not the least curious part about the system is the simultaneity of the invention—of the principle of alternating-current motors, we had Ferraris and Tesla within a short time of each other; then, after a lull of some years, Bradley, Dobrowolski, Haselwander, and Wenström suddenly blossom forth with a fully-developed rotary-current system, and in the forthcoming Frankfort Exhibition the most noticeable feature would seem to be these rotary-current motors, of which two systems at least, and possibly more, will be represented.

EXPLANATORY.

LOOPS, LINES, ETC.

Before continuing the relation of experiments, it will be well to consider certain comments—some contained in published correspondence, some sent in private letters. Practically, Mr. J. T. Sprague agrees that my "experimental facts are simple and soundly stated." He would, however, push my statements further, a proceeding to which I have not the slightest objection. Circuits and the interference of circuits are to me the fundamental principles underlying electrical phenomena. The phenomenon of current necessitates a circuit. The phenomenon of "field" necessitates loops or complete circuits. Whether the field is made up of a definite number of loops, each of which can have a varying action, as Mr. Sprague seems to imply, or whether the action of each loop is a constant quantity and the number of loops vary, as I prefer to put it, must be left to the future to decide. Mr. Sprague will no doubt forgive me for quoting a letter not sent for publication. In it he says, "My idea rivets together matter and energy. The force is not outside, but *in* the chain. The energy, which is the true source of force, is linked to the matter and actuates the forces of matter, not vaguely and in a mass, but atom by atom." Probably from the results of experiments of De la Rue, Dr. Shettle, and others, there is something of a spiral character in the field, but, all things considered, at the present time I prefer the convention, the field consists of "loops of force," each loop possessing similar and equivalent properties. If the loops of force around a conductor consist of series of concentric loops, rings, or circuits, then Mr. Sprague's view must, I think, prevail, if they possess a spiral nature; even if it approximates very closely to concentric rings, the probability that Mr. Sprague's view is right is no greater than that it is wrong. I have had the curiosity to look up my criticism of Mr. Sprague's book, written in 1875, and find that my views have not greatly changed. Then I insisted upon the "circuit," I doubted about "repulsion" and I disputed the accuracy of the "law of inverse squares," as being generally applicable. Most people now use the convention "circuit" both for electrical and magnetic phenomena, few will be found to support the theory of repulsion, and no one will hold to the law of inverse squares in magnetic phenomena except as a mathematical truism, applicable only in cases where matter is non-existent. I hold that Mr. F. C. Webb should have the credit among moderns for giving the deathblow to "the earth a reservoir," to "action at a distance," and similar rubbishy theories. He, I think, proved the "circuit," and Ohm's, or a similar law, applicable to what he knew as the "inductive circuit." Snow Harris was heterodox, so was Webb, and so was Sprague, and so were others, yet the tendency of modern thought is in the direction pointed out by these men, and many of the mushroom electricians of to-day know neither their work nor the credit due to them. I have to say this because, although I might be able to agree with Mr. Sprague, such agreement carries little or no weight with the ultra-orthodox.

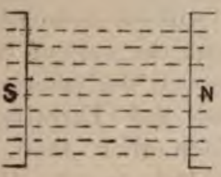

FIG. 1.

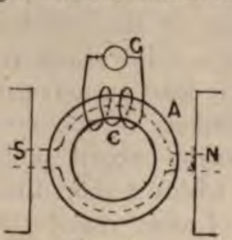

FIG. 2.

A correspondent whose knowledge of dynamo work is extensive, and whose opinion I value very highly, challenges me to explain by the loop theory why the brushes of a Gramme ring, when stationary, must be at right angles to their position when running to get E.M.F. He says: "If you will make and break the field of an ordinary dynamo (possibly not your experimental one) you will find that to get any E.M.F. from the armature the brushes must be at right angles to the position in which they are running." My explanation of this fact is very simple and is in perfect accord with all I have said. It is not necessary, for the sake of argument, to consider leakage lines. Let N, S represent the field magnet poles, and when the field is made we may assume it to be uniform, as indicated in the diagram, Fig. 1. If an iron core is inserted in the air space as in the second diagram, the loops of force crowd into the iron core, and divide equally, one half the loops going through the top half of the core, the other half going through the bottom half. Consider a single turn of wire around the core at C, connected to a galvanometer, G. On making the field we get a deflection. Increasing the turns on the core, and making the field, gives a proportionally increased deflection of the galvanometer The greatest number of turns of wire, and therefore the greatest deflection, is when the whole of the top half of the core is covered with wire, as shown in the third diagram. The same goes on with the wire on the lower half of the core. The wires on the two halves being in parallel, reinforce each other as to current when contact is made at opposite ends of the axis of core.

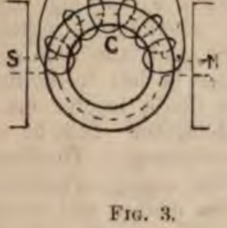

FIG. 3.

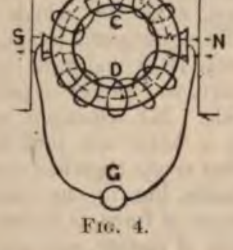

FIG. 4.

This explains why maximum E.M.F. or maximum current is obtained under the conditions given.

I may point out, however, that any E.M.F. and any current can be obtained in a coil placed at any point on the core, except at the points on the axis of the loops of force. There is no E.M.F. impressed or current generated in a coil placed parallel to the loops of force on the line of the axis.

C. H. W. B.

REGULATION OF CONSTANT-CURRENT GENERATORS.*

BY ALEX. DOW.

Electric power expressed in watts is a product of two factors, the E.M.F. and the volume of the current carrying the power.

A change in the total power of the current may be expressed by a change of either factor, or of both. In distributions of electric energy it is usual to provide for adjusting the production to the requirements of the work by varying only one factor, the other being maintained constant from minimum to maximum production. Thus we have two commonly recognised methods of distribution at constant E.M.F., and with constant current. There are cases in practice where both factors may vary; for instance, when a series-wound dynamo operates one series-wound arc lamp, or when a shunt-wound machine is employed to charge one set of accumulators; but you will notice that in such cases there is but one device absorbing energy. Where there is more than one absorber, the difficulty of keeping each of these in unison with the other compels the adoption of a one-factor regulation of the generator.

It is impracticable to supply from the same generator two devices, one of which requires a low E.M.F. and a large current, and the other a greater E.M.F. and a smaller current. But if they are alike in either requirement their operation together becomes practicable.

We may say that it is this operation of more than one receptive device by the one generative circuit, this division of the energy, that has caused the differentiation of the two methods of distribution. And designers of electrical machinery have adapted their apparatus particularly to one or the other of these operating conditions, and have in their dynamos provided for the maintenance of the selected condition. This paper is a study of the regulation of constant-current dynamos.

The book of the constant-current dynamo is yet unwritten. The constant-potential dynamo has its literature by libraries, and the literature of the transformer is accumulating daily, but the constant-current dynamo is neglected by the bookmaker. Those who wish to study it must go to the machine itself, and they will find it the least understood and the worst treated of all electrical generators. I have thought that a paper on this subject based on observation and practical study would be of interest to the club.

The theory of the dynamo-electric machine as commonly taught is that the E.M.F. developed by any dynamo depends on the rate at which the conductor under induction cuts lines of magnetic force. For the purpose of this paper we will accept this theory; and as regulation of the output of a constant-current dynamo means changing its E.M.F., we see that any method of regulation is necessarily a method of changing the rate of cutting of lines of force.

In practice, this cutting is by the conductors of an armature revolving in a magnetic field, and we see several possible ways of obtaining a change of rate. We can change the velocity of the conductor, run the armature at a lower speed, and so do less cutting in a given time. Or we can reduce the number of lines of force intersecting the path of the conductor—reduce the "strength of field," as we say, and so give the armature wires less lines to cut. Or, third, we can change the length of conductor; the greater effective length of an armature wire there is in the field, the more cutting it will do per revolution. Any of these, or any combination of them, will serve to regulate the E.M.F.

The first way is the simplest and most efficient. Change of speed will alter the E.M.F. of a dynamo, without complication and with absolute accuracy, right down to the point at which it merely charges its own field magnets. I have an old table in my possession showing the proper speeds of certain dynamos for any number of arc lights from one up to the limit of each machine. It looks a little odd to-day to see the speed stated as "60 revolutions for one light and 16 revolutions for each additional light." We are accustomed to setting speed for full load, and letting our automatic governors or engines or dynamos take care of any reduction of load. My own practice, when I have a plant with engine and dynamo capacity much in excess of present requirements, is to set speed at the minimum and increase it from time to time as increased business requires. Most automatic cut-off engines will govern at any speed within a wide range; and I gain electrical economy, a reduced friction card, and a saving in steam by reduction of cylinder condensation. The theoretical economy is obvious. The belt power is as torque by speed. The torque remains constant with the current, and the total power is reduced directly with the speed.

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* Paper read before the Chicago Electric Club, April 6, 1891.

In water power plants regulation by speed is common. I saw recently a neat instance of this. The plant is two 20-light arc dynamos. There is an automatic governor to each dynamo, but these are depended on only to compensate for difference of load between the two machines. The attendant is guided by the ammeter of the machine carrying the heaviest load, and regulates entirely by the hand wheel controlling the water gate. It is interesting to note that the brushes need no attention when change of load is met by change of speed.

Regulation by changing the strength of the field has been brought to perfection in constant-potential working in the shape of compound winding. It is used also in constant-current work, many of the most familiar devices depending primarily on change of field. But compound winding is not used to any extent; such winding for constant-current is "a hard road to travel." The first difficulty is to design a commercially and mechanically practicable shunt field for high voltages. Shunt-wound arc dynamos have worked up to 1,200 volts, and worked well under favourable conditions. But 1,200 volts is too low for recent practice, and conditions are never favourable to an arc dynamo—well, hardly ever. With the open-coil dynamos which have two or three independent commutators connected in series, it is possible to compound by a shunt connected to one commutator only, the shunt thus taking half or one-third of the total voltage. Power generators of this type are doing excellent work, but the extreme changes of lead under variation of load limit the applicability of these machines. Of course an automatic brush-rocker is suggestive as the one thing needed to make them generally useful, but to make a brush-rocker keep step with the instantaneous changes of field is another hard road to travel. I believe that up to date, when a sudden change of lead is in order, the compounding gets there ahead of the brushes every time.

To make a brush-rocker work properly on any style of power generator is a nice problem. The changes in arc lighting are perfectly manageable. It's the utterly unreasonable changes that come when you have a lot of big motors on a series circuit, that show just how much momentum a rocker with little inertia and a perfect dash-pot can acquire. I counted the swings on such a rocker once when a big motor had been flicked off suddenly. I counted up to 47 and it was not quite done then.

But I believe that compound winding, with or without a rocker, will ultimately be the accepted method of regulation for constant current.

Before taking up the study of regulators of the field-changing class, I must say something about armature reaction—*i.e.*, the influence of the armature magnetism on the density of the field. A good deal has been written on this subject in connection with the Stanley constant-current alternator. I have not seen that machine, so I can say nothing about it, but any account of the familiar direct-current regulators must take reaction into the reckoning. It is a feature of all, and the most prominent feature of several, although it is invariably overlooked in published descriptions.

I want to make clear by a few diagrams the part which the armature of a dynamo constitutes in its magnetic circuit. I need not begin by a definition of the magnetic circuit; that idea, though it is only a conception of the last two or three years, has already reached the advertising department. But I state its fundamental law in order to lead up to the statements to follow. It is that the magnetic flux in any circuit—that is, the total number of lines of force, or what we call the strength of field—is directly proportional to the magnetic motive force; that means, in a dynamo, the number of ampere-turns in its windings and is inversely proportional to the magnetic resistance of the circuit. This last means that if the iron of the dynamo is poor, or the space between armature core and pole-pieces is wide, or the field magnets long and thin, we won't get so strong a field for the same ampere-turns as if the iron were good and the clearances small and the magnets stout and short.

Now the magnetic circuit of a dynamo is a compound one. It is not all iron, nor is it all air; it is iron and air and copper armature wire. The magnetic flux in this circuit under a given magneto-motive force applied to the field magnets can be calculated, when the armature is not traversed by current, from the known magnetic resistances of the iron and air and copper. But so soon as there is current in the armature the circuit becomes complex as well as compound. The armature becomes a magnet in its own right in virtue of the current circulating in its windings, and its magnetism may and does oppose that of the fields. So that the total magnetic flux or strength of field is changed, and changes further as the current of the armature increases.

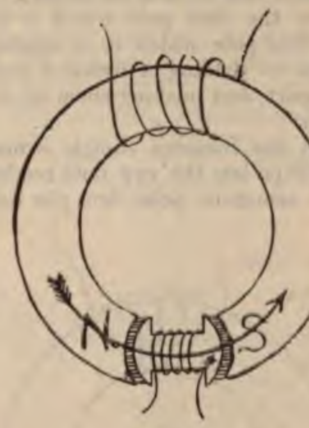

FIG. 1.

To illustrate this by my diagram, Fig. 1, let us conceive this armature to be free to move on its axis, but not traversed by current, and the field excited by a constant current from some external source. We have thus a magnetic flux, from pole-pieces N to pole-piece S, which takes as part of its path the iron core of the armature. Here we have an ordinary compound magnetic circuit.

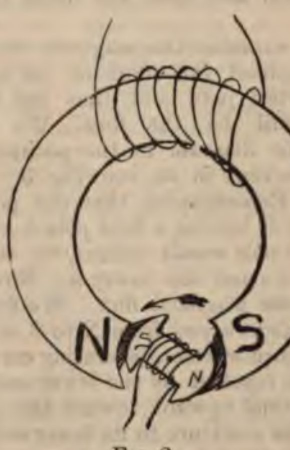

FIG. 2.

Now we will conceive, Fig. 2, that the armature also is excited from some external source in such manner as to produce polarisation, *n* and *s*. We have now a marked tendency to get attracted poles in line in such manner as to get the best magnetic circuit, to get the straightest path for the line of force. Or we may say in such manner as to form from one big magnet the two independent magnets, the field and armature. This is what I call a complex magnetic circuit. There are two magneto-motive forces operating to produce a flux along the same path.

Our diagram as it stands only needs a commutator and brushes to be a motor. This pull between attracted, and corresponding push between repelled, poles is the working power of a motor. The commutator acts by reversing the polarity of the armature at the proper instant so as to make the attracted armature pole a repelled one and cause it to be pushed around into position to be attracted by the other field pole, and so on indefinitely.

Now we will conceive, Fig. 3, that we have a belt on our armature pulley and are driving it up to speed, and that the ends of the armature coil are closed on one another, say through an arc lamp. There will be currents induced in the armature coil, and these currents will polarise the core in such manner that each of its poles, *n s*, are attracted and held back by the field pole which it is leaving, and repelled by the field pole which it is approaching. That is, the work done in driving a dynamo, pulling attracted armature poles apart, and pushing them up to other poles which repel them.

I have selected the Siemens shuttle armature with one coil because its shape lets the eye note readily the relation of the field and armature poles, but you understand that the many-coiled armatures have just such poles and attractions and repulsions. The only difference is that their polarity is more constant, as the one-coil armature is without current twice in each revolution, while the many-coiled armature is able to maintain its current always. And you understand also that the position of the brushes decides the position of the polarity due to the armature currents, as it is to one brush and from the other that the currents circulate.

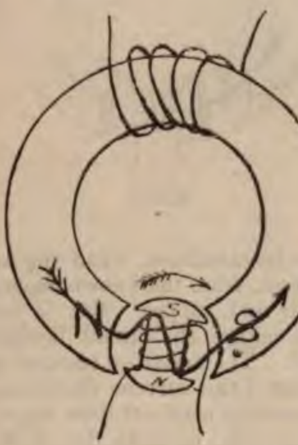

FIG. 3.

Now let us examine the magnetic circuit as a whole. We have recognised the effort of the magnetic flux to secure the shortest path and that the shorter the path the greater will be the flux. We will place the armature of our diagram in the position for maximum induction of current in its coil, Fig. 3. The rotation is right-handed. Remembering that the pole of a dynamo armature which is leaving a field pole is always of the sign which that field pole would attract, we see that the upper armature pole is *s* and the lower *n*. Now let us lay out the course of the magnetic flux. We find that the lines which went straight across from N to S of the field magnet when the armature was not generating current cannot do so now. They are repelled by the lower end of the armature and obliged to bend upward toward the upper end. And they traverse the armature to its lower end, and again bend upward to reach the S field pole. You see that the resultant polarity of the area between the field magnets, which was formerly a straight line from pole to pole, is now a diagonal line, and that its departure from the straight line will be the greater the more the armature magnetism increases. That is armature reaction. I find it convenient to think of the reaction state as a lengthening of the magnetic circuit. You see the lines of force now take a crooked long path instead of the short straight path they had before the reaction commenced, and the effect on the field is just the same as if the magnets had been made longer, or the air space made wider. You don't get so strong a field when reaction sets in, although your exciting current or magneto-motive force remains the same. Indeed, in dynamos designed to take advantage of this reaction you don't get so strong a field for a greater exciting current.

(To be continued.)

SOME RECENT IMPROVEMENTS IN LEAD SECONDARY BATTERIES.*

BY J. T. NIBLETT, MEMBER.

(Concluded from page 395.)

Storage Cells for Electric Traction.—The idea of locomotion by means of electricity is just now attracting much attention, and it is therefore wise for electrical engineers to seriously consider the many different systems now being advocated, so as to determine which of them is the most feasible, safe, and economical. Much may be said in favour of the method of conveying the electricity through overhead conductors, the utilisation of the rails, or separate insulated high conductivity conductors, as the current leads; or of the method of "picking up" the current from underground mains. If, however, a storage battery can be devised which shall be capable of withstanding the excessive electrical strain incidental to a rapid and irregular rate of discharging, and the mechanically disruptive effect which always seems to attend concussion and jolting, and greatly tells upon accumulators when used for such purposes, then the self-contained storage battery system would be found to compare most favourably with any of them, both in point of simplicity and economy. When devising batteries suitable, say, for heavy tramcar work, we are met by many difficulties. Owing to initial cost, a small number of cells must suffice, and they must therefore be constructed to run many hours with one charge. They should be capable of being quickly recharged and then reinstated. Their internal resistance should be low, and their capacity great, for they not only have to develop sufficient electrical energy to carry the car over irregular, undulating, and rough roads, on which at times the pulling power of the horses ordinarily employed is strained to its utmost limits, but they have to carry their own dead weight. The additional weight of the battery may probably represent fully 50 per cent. of the total weight of the combined car, motors, gearing, cells, and passengers. A reduction of 1lb. in the weight of the batteries, if the energy-storing capacity remains the same, represents a gain equivalent to that amount of energy required to carry 1½lb. of car. From this it will be seen that weight is a most important consideration. The metal grids or plates must be strong and rigid to withstand the jolting and oscillation, and must be so constructed that the pellets of active material are not liable to fall out. Strength of grid usually means increased weight. To keep the plates securely fixed, distance-pieces or similar devices must be introduced. The placing of insulating bars, frames, or distance-pieces between the elements reduces their active surface, increases the internal resistance, decreases the solution space, and adds to the weight, and should therefore be avoided as much as possible.

Solid Storage Cells.—Recently many of those interested in the subject of electrical storage have devoted much attention to the production of so-called solid batteries. In this new type of cell the usual liquid space is filled in, either with some highly porous and absorbent compound, which is made conducting by the addition of acidulated water, or by an acid gelatinous mass. As examples of this form of cell, I shall draw your attention to those devised by Mr. Barber-Starkey and Dr. Schoop. One great drawback to the employment of a viscous, gelatinous, or solid porous electrolyte resides in the fact that when such substances are interposed between the plates no free circulation of the conducting liquid is possible. In secondary cells the activity of the elements depend entirely upon chemical action; and as the electrolyte is the medium through which all the necessary reactions take place, it seems probable that anything which prevents its free access to the active material, or in any way impedes its circulation, must be detrimental to the cell and lead to loss of efficiency.

For some years I have been giving much attention to methods of producing a mechanically solid storage cell. After much experimenting and many failures, I have at last succeeded in making a form of cell which is really mechanically solid, and which seems to be, as far as my experience takes me, quite indestructible. In the new cell there is ample space for the liquid, which, owing to the peculiar construction of the elements, is always slowly circulating throughout all the active parts. Some experimental cells made about two years ago have been under constant trial and test, and although they have been subjected to much bad and improper treatment, they are still in excellent condition, and giving very promising results. Recently, the battery has assumed a more practical and commercial form, but as it is still in its experimental stage, I must defer a description of its construction and capabilities until some future occasion.

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* Paper read before the Physical Society of the Glasgow University, 13th January, 1891.

I am strongly inclined to think that no real test of any form of storage battery can be made in a few weeks or even months. To study the effect of time, and constant charging and discharging, combined with periods of rest, both when in a state of charge and discharge, appears to me to be the only true test for any battery destined for commercial and everyday use. A laboratory test may be reliable enough for cells constructed for stationary purposes, but when they are to be employed for traction, or as portable batteries, nothing but an actual and prolonged practical trial ought to be relied upon.

The Barber-Starkey Solid Cell.—Mr. Barber-Starkey has succeeded in transforming some of the ordinary grid form of cells into a mechanically solid battery by filling in the space between the grids with a dry mixture of sawdust and plaster of Paris, and then rendering it conductive by saturating it with dilute sulphuric acid. By trial he found that the proportions of these materials which gave the best results were one part commercial plaster of Paris mixed with 2½ parts of a non-resinous wood sawdust. When the liquid is added the porous mass quickly solidifies, and when in this condition it is said to effectually keep the plates from warping or buckling, and also to prevent the pellets of active material detaching themselves from the metal grid. A number of cells in Mr. Barber-Starkey's private installation were treated in this way, and were fully charged up and then allowed to stand idle for many months. Ultimately, when the cells were tested they gave their full potential, and in every other respect they appeared to be in excellent condition. More recently a practical test has been given to this form of cell. A whole set of batteries used for driving a car on the Barking-road tram rails in London were treated in the manner prescribed by the inventor, but after some months' trial they had to be abandoned, owing to their loss of efficiency and current capacity.

The Schoop Solid Cell.—A form of battery deservedly attracting much attention just now is one devised by Dr. Paul Schoop. The novelty in this battery does not consist so much in the construction of the plate as in the electrolyte, which is of a solid gelatinous nature. The elements are of the grid form, triangular in section, and containing only about two-thirds the quantity of active material usually employed. The electrolyte used is made by adding sulphuric acid to silicate of sodium. In preparing the electrolyte three volumes of a solution of pure sulphuric acid and water, specific gravity 1,250, are mixed with one volume of dilute silicate of sodium, specific gravity 1,180. This mixture remains at first quite fluid, but it gradually becomes more and more viscous, and in about two hours it assumes a gelatinous form. After a period of 24 hours the maximum stiffness is apparently reached. When set, the mass is a hard jelly-like substance of a slightly bluish tint. When under electrolytic action no alteration in its appearance is apparent. If bubbles of gas are given off from the plates, they merely push the gelatine away and escape upwards, and as they ascend the elastic material immediately closes behind them and remakes contact with the plate. On the cell arriving at its state of full charge, a small quantity of the dilute acid solution is forced out and floats on the top of the gelatine, and during the discharge this liquid is gradually reabsorbed and finally disappears.

During the greater part of last year the Schoop cell has been under test by Prof. Kohlrausch, of the Hanover University. The cell selected for trial was one especially designed for portable work, such as driving cars, lighting trains, and all kinds of rough works. Perhaps the following data as given by Dr. Schoop with reference to this cell may be of interest :

Number of plates	17
Thickness	2·5 millimetres
Weight of plates	8 kilogrammes
,, electrolyte	3 ,,
,, containing cell	0·7 ,,
Outside box length	125 millimetres
,, breadth	160 ,,
,, height	205 ,,
Total outside height of cell	250 ,,
,, weight of cell	11·7 kilogrammes

The total current capacity of the cell was found to be 70 ampere-hours when the rate of discharge did not exceed 9 to 10 amperes. Under normal conditions the current efficiency was stated to be 89 per cent.

After a series of tests extending over many months, the cell was taken to pieces, and on examination the gelatine was found to be in an excellent condition. The grids did not show any signs of deterioration either by warping or buckling, while the pellets of active material did not show the least sign of looseness or tendency to come out. Prof. Kohlrausch thinks it possible that the plates, if in daily use, may last at least two years, giving their full current capacity ; after that period they may still be expected to do good and useful work for an additional period of three years.

Sulphating and its Removal.—One of the chief causes of loss of efficiency in accumulator cells is due to sulphating. This troublesome white sulphate of lead usually forms on the exposed parts of the metal support, on the surface of the active material, or just where it is least wanted—namely, at the junction of the metal support and the peroxide. The formation of this sulphate is probably due either to impurities in the oxide employed, deleterious substances in the lead or lead alloy used for the frames, or chemical impurities in the sulphuric acid or water. If a cell is allowed to remain idle and without charge, its elements frequently sulphate. A suggested cure is to charge at a somewhat higher rate than the normal specified rate, and to continue the charging for some little time after the cells freely give off gas. This process usually either reduces the sulphates into the peroxide, or causes it to fall away from the plates.

Mr. Barber-Starkey found that by adding a small quantity of carbonate of soda to the acid electrolyte, it not only reduced the tendency of the elements to sulphate, but rapidly removed it when already formed. This action is probably due to the conversion of the sulphate first into carbonate of lead and then into the peroxide, or it may be owing to the fact that sulphate of lead is sparingly soluble in a solution of sulphate of sodium.

Mr. W. H. Preece, F.R.S., seems to have given the acid-soda electrolyte a good deal of attention, and has put it to some thoroughly practical tests. One trial consisted in taking six new accumulator cells, which were made as nearly as possible identical in every respect, and using in each different solutions composed of various percentages of sulphuric acid and water, and sulphate of sodium.

The sulphate of sodium solution used was prepared by adding carefully strong sulphuric acid to a saturated solution of commercial carbonate of soda. The addition of acid was continued until carbonic acid gas ceased to be given off, and all effervescence was stopped.

The following table shows the composition of the various mixtures tried. The first column indicates the number of the cell :

No. of cell.	Sulphuric acid.	Sulphate of sodium.	Water.
1	5 pints.	5 pints.	15 pints.
2	5 ,,	4 ,,	16 ,,
3	5 ,,	3 ,,	17 ,,
4	5 ,,	2 ,,	18 ,,
5	5 ,,	1 ,,	19 ,,
6	5 ,,	none.	20 ,,

The six cells were then filled respectively with these solutions, and were carefully charged and discharged continually for a period of 12 months. On the expiration of this term the elements were thoroughly examined. The cells containing solutions numbered from 1 to 5 were found to be in a much better condition than No. 6, which only contained the dilute acid without the soda sulphate. No. 5 solution seems to have given by far the best results. In this cell the plates were found to be in perfect condition, and did not show the slightest signs of sulphating.

As an example of the beneficial results to be derived from the use of acid-soda solution, the following may be worthy of mention. It is said that at the Central News office in Ludgate-hill, London, a number of large lighting cells had been lying dry and idle for about two years. The plates were found to be thickly encrusted with a hard white sulphate. With the ordinary electrolyte and a charging current of from 10 to 15 amperes, no improvement was observed after two charges of eight hours per day ; but after adding about half a pint of strong carbonate of soda solution to each cell, and with the same amount of current going in as before, the plates soon improved, and in a few days all the elements presented a beautiful appearance.

When removing sulphate by this method, it is much the best way to take out the desulphating solution after the plates have been brought to a healthy condition, and to replace it by the ordinary dilute acid electrolyte, otherwise the negative plates are said to deteriorate.

The Electrolyte.—Those accustomed to working with secondary cells can usually obtain a fair conception as to their state of charge and general condition by simple inspection. When fully charged the positive plates* are of a very dark greyish-brown tint, the negatives a dark slate colour. During the discharge both plates gradually turn a somewhat lighter shade. When quite exhausted, the plus elements are a light chocolate hue, the minus a light slate. Should the colour of the peroxide plates change to a drab, it either indicates that the polarity of the cell has been reversed, or that the active material is becoming badly sulphated.

The usual and more accurate method of ascertaining at any time the condition of a cell as to charge, is to measure the density of the electrolyte by means of a hydrometer, or, as they are sometimes termed, an acidometer. In a newly set up cell, as soon as the acid electrolyte is added, a large percentage of the sulphuric acid is quickly absorbed by the active material, and goes to sulphate of lead in both plates. During the "formation" and subsequent charging, the reducible sulphate formed is reconverted either into oxide or spongy lead, and the acid is reinstated in the solution, the density therefore rising. Different makers specify different densities of solution. The usual thing for a starting electrolyte is a density of about 1,180. With such a solution the density may vary from 1,150 to 1,200, or even 1,250, when the cell changes from a condition of no charge to full charge. Some advocate acid solutions having densities as high as 1,400 to 1,500, but with solutions containing as much acid as these, although the conductivity of the liquid is greatly increased, the tendency of the active materials and metallic supports to injuriously sulphate is greatly increased.

Hydrometers, or Acidometers.—The acidometers employed to test storage cells are usually made of glass or vulcanite, or some material which is unaffected by the corrosive action of the solution.

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* In this paper, whenever speaking of the positive or plus plate, or element, I refer to that plate which contains the peroxide of lead ; when referring to the negative, or minus, I wish to indicate that which holds the reduced oxide, or spongy lead.

When the density requires to be read off with great accuracy, Beaumés' or Twaddell's standard instruments are used. In using Twaddell hydrometers for liquids heavier than water, to reduce the readings on these instruments to degrees of density, the number read off on the scale is multiplied by five and the product is affixed to unity, after the decimal point. The ordinary commercial form of density indicator as now used, is either a plain cylindrical or flattened bulb tube terminating with a thin hollow stem. The instrument is weighted with fine lead shot or mercury, and a paper calibrated scale is sealed in the stem. The usual range is from 1,100 to 1,250, taking the density of pure water at 60deg. F. as 1,000.

Hicks's Glass Bead Hydrometer.—A new form of hydrometer, very useful for testing the density of the solution in cells, has been brought out by Mr. J. Hicks. This instrument is a development of the old-fashioned glass bead arrangement, as used by gaugers for determining the strength of spirits. In gauging spirits a number of glass beads, having more or less weight in comparison with their volume, are taken, and by actual trial are numbered and marked. To find the specific gravity of the liquid under test, these beads are tried one after another until two are found, one of which sinks and another just floats. The density is ascertained by taking the mean of the numbers on these two beads. Occasionally, it is found that one of the beads show no tendency to either sink or float. The liquid then has exactly the density marked on this bead. The hydrometer, as devised by Mr. Hicks, Fig. 28, consists of a perforated flat glass tube, of such a size as to easily slip between the edge of the plates and the glass containing cell. Within the tube are either three or four small flattened specific gravity beads, of different colours, and placed one above the other, the lightest uppermost. These coloured floats are capable of freely rising and falling in the tube, which they nearly fit. The floats may be balanced to any desired density. In the four-bead tube the top float, which is coloured green, will float when the specific gravity reaches 1,150, the violet at 1,170, the blue at 1,190, and the red at 1,200. The densities are plainly marked on the back of each float.

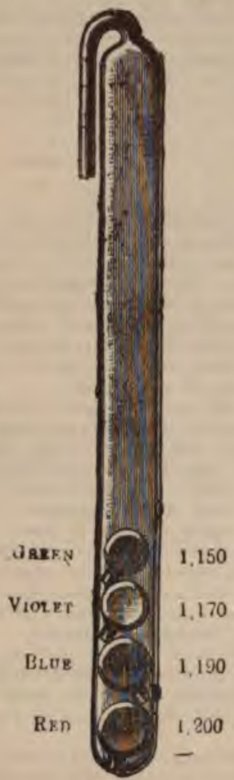

FIG. 28.

The Holden Hydrometer.—A very sensitive and useful form of hydrometer has been devised by Captain Holden, R.A. This instrument consists essentially of a light glass float, with a long narrow glass stem, which is free to move in front of a fixed scale, Fig. 29. The float is cylindrical and about 8in. long; this terminates in a thin rod, between 8in. and 9in. in length. Owing to the large relative difference between the amount of displacement of the bulb and stem, these instruments may be made to have a very open range. A difference in the scale reading of 7in. may readily be obtained with an alteration of density of from 1,150 to 1,200. The densities are not marked upon the glass float, but are pointed off on a vulcanite scale. The scale may be fixed to a lug or connector of the battery elements by means of an indiarubber band, or some other clamping arrangement. The lower end of the scale is V shaped, and in adjusting the point must be brought down to just touch the surface of the liquid. The float freely moves up and down in front of the fixed scale; the readings are taken from the top of the pointer. Owing to the great sensibility of these instruments, the temperature of the solution should be taken into account if very accurate measurements are required. To this end a thermometer should be placed in the solution, and then by reference to a table of temperature corrections the densities may be read off with any degree of accuracy required. The scale may have a sliding arrangement affixed to it, which by adjustment may be made to give offhand the necessary corrections. When used as a check in a "master" cell, if the requisite data as to density, true current capacity, and internal resistance be known, then the scale may be calibrated in terms of ampere-hours, and may be used as a check either in the charging or discharging operation.

These instruments can be made either in glass or vulcanite; they are extremely accurate, easily visible, and do not stick to the sides of the cell. Owing to their high sensibility, a most interesting experiment may be made with this form of hydrometer. If one of the most sensitive of these instruments be placed in a cell from which a very large current is being taken, the gradual subsidence of the pointer may readily be observed.

The Volk Accumulator Indicator.—Mr. Magnus Volk is just introducing a neat little instrument for indicating the condition of a cell by simple inspection. The apparatus consists of a light glass cylindrical bulb of sufficient length to reach nearly from the top to the bottom of the electrolyte. By this arrangement the average density of the solution is obtained. The bulb is submerged at all times, so any difference in the level of the liquid does not interfere with the readings of the instrument. The glass bulb is suspended in the electrolyte from the end of a frictionless spring jointed arm, by means of a very fine platinum wire. A suitable pointer is fixed on the moving arm of the instrument, and travels over a scale which may be divided either into degrees of density or into any arbitrary divisions suitable for the work of the cell. The scale is usually pointed off in terms of ampere-hours, which may be used to afford an approximate indication of the number of ampere-hours taken from the cell at any given period. A double reading scale may be used, which gives degrees of density and also the corresponding current indication. The instruments may be made of any reasonable range, say, from 1,150 to 1,200, or from 1,170 to 1,250. To prevent the acid spray or fumes from affecting the metal work of the instrument, the whole thing is covered by a tightly-fitted case, a small hole only being made to give free play to the suspension wire. By means of a small mirror, placed at any desired angle, the scale readings may be taken if the instrument is used where the cells are in inaccessible positions.

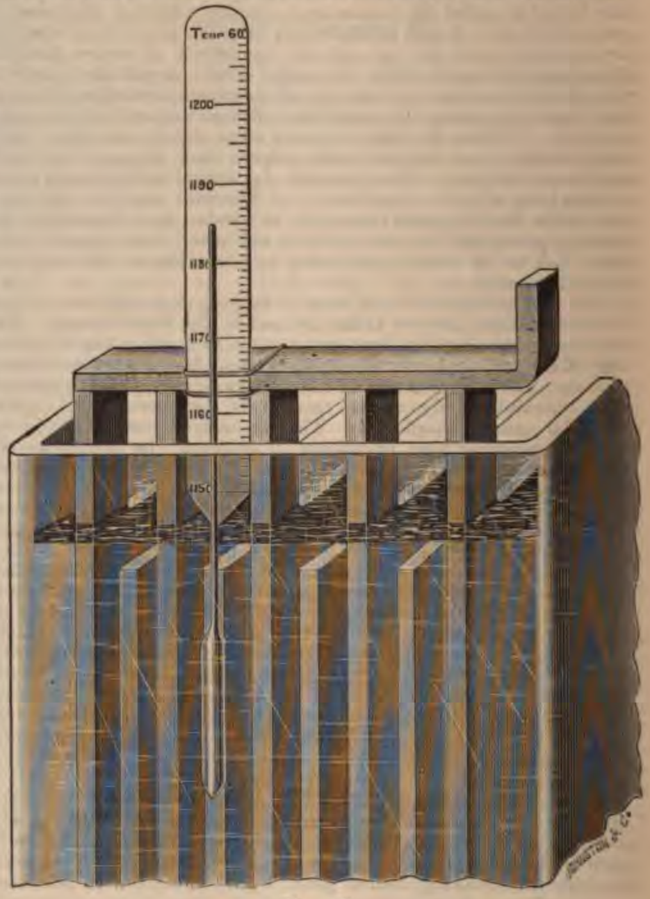

FIG. 29.

In conclusion, I fear that some apology is necessary for putting my subject before you in so unscientific a manner. When commencing this paper it was my intention to introduce some comparative data as to the relative merits of a few of the cells that I have endeavoured to describe. I also intended to say a little with reference to the terms current capacity, absolute current, absolute energy efficiency, working current, and working energy efficiency, much confusion being sometimes caused by a misunderstanding as to the proper interpretation of these terms. As I proceeded with my subject, however, I found so many very interesting developments of both the "Planté" and "Faure" cells, that I determined to adhere strictly to a descriptive style, and to leave all theoretical considerations, together with the results of my own investigations, until some future occasion.

The electrical, chemical, and mechanical problems involved in the construction of apparatus for the storage of electrical energy are most fascinating studies, and to me they have an almost irresistibly alluring influence. Secondary batteries lend themselves readily to a vast number of scientific, economic, and artistic purposes, but at present our knowledge of their laws and possibilities is very limited. Yet I feel firmly convinced that they will ultimately play a most important part in the many applications of electricity which are daily opening out. The wonderful progress which the lead accumulators have made since their commercial introduction is very striking, though even the very best and most perfectly-constructed cells now made still leave much to be desired.

INSTITUTION OF ELECTRICAL ENGINEERS.

ADJOURNED DISCUSSION ON MR. ESSON'S PAPER, "NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS."

Authorised Abstract.

Mr. F. V. Andersen supplemented his former remarks by saying that in considering the question of sparklessness in dynamos, account should be taken of the lead of the brushes, for very large currents could be collected without much sparking if the lead was not limited to a small angle. Mr. Esson's formula for the limiting currents was doubtless true if the brushes be at the polar tips; this, however, meant a considerable lead, and a change of, say, 10 per cent. in the load would necessitate the readjustment of the brushes. Now, for central station work, it was desirable that machines should have a very small lead, and this could be obtained by having long powerful fields. Referring to the cost of multipolar machines, he said that their chief characteristics were short fields, and shallow armature cores. There was, however, no difficulty in making two-pole machines with short fields, provided large lead was permissible, or the maximum load decreased as the limbs were shortened. He therefore considered that there was no gain in splitting up the constructive material to form multipolar fields.

Mr. Housman greatly appreciated Mr. Esson's term "volume of current," but thought the fact that it meant twice the ampere-turns should have been made more clear. The whole of the author's argument in favour of multipolar machines, he said, depended on the length of the air space necessary to prevent sparking being generally greater than that required for the copper. As regards the relations of "volume of current" and output to the diameter of armature, he thought that for equal rise of temperature the "volume," v, was proportional to diameter to the power three-halves $d^{\frac{3}{2}}$, hence the output for the same circumferential velocity would vary as $d^{\frac{5}{2}}$. Under the same conditions of circumferential speed and induction, the loss by hysteresis varies as d^2, and consequently the rise of temperature due to this loss was the same for all sizes of armature. Foucault current losses, however, varied as d^3, and in general these were much greater than those due to hysteresis. In practice he had observed that the maximum safe output for a given armature was reached when the sum of the hysteresis and Foucault current losses was about equal to the losses in the conductors. The rapidity with which heating due to Foucault currents increased with the diameter prevented the output varying in so great a ratio as $d^{\frac{5}{2}}$, and as a rule it increased in a ratio somewhere between d^2 and $d^{\frac{5}{2}}$. Referring to the limiting non-sparking load, he said that Mr. Swinburne's hypothesis (on which the author bases his arguments), which says that the self-induction of an armature coil is small, and, therefore, only a weak field is required to effect sparkless reversal, was not jvstified. The coefficient of self-induction of an armature section, as measured by a ballistic galvanometer placed in circuit with a coil wound close to a disconnected section, he found to be very considerable, and by passing various currents through the latter the variation of the coefficient with an armature current had been ascertained. From the coefficients so determined he had calculated the strengths of field necessary to effect reversals, and by measuring the field round the armature had determined the non-sparking lead for various currents. These calculated values agreed fairly closely with those found by actual trial; and in the case of a small air space dynamo a field of 3,000 C.G.S. units was necessary to produce sparkless commutation, the maximum field being 7,000. To further investigate how far Mr. Swinburne's hypothesis was correct he had run a dynamo at half load with different brushes, the first set covering one commutator segment, and the next bearing on only half a segment. In the latter case the lead required was much greater than in the former. If the hypothesis was correct a very small change of lead should double the field, but in practice the additional lead was considerable. The difficulty of variable lead could, as was well known, be got over by using "commutating magnets" or "reversing pole-pieces." Those shown in Mr. Swinburne's paper on "Armature Sections" were quite inadequate as regards size, for in practice they had to be much more substantial. As a rule, the number of series-turns on these "commutating magnets" was about ·75 times the effective armature-turns for single-magnet machines, and for double-magnet machines 1·25 times the effective turns. On the question of efficiency, he said that multipolar machines could not compete with two-pole ones, for the weight of iron was not diminished in so great a ratio as the increase in number of poles, and hence both the hysteresis and Foucault currents losses for a given output were greater in multipolar machines. Neither would the magnets be so light as stated in the paper, and the economy obtained by having all the winding on one magnetic circuit was all in favour of the two-pole type. A difficulty, however, was met with in large two-pole machines, owing to the energy stored up in a single section of a large machine when a strong current is passing being very great. This caused considerable trouble, but he thought it might be overcome by subdividing the winding.

Mr. Swinburne said Mr. Esson should be congratulated on bringing forward a subject that had never before been systematically discussed. In England, engineers had settled down into making a regular type of two-pole single-magnet drum machines, and on the Continent, even small machines were made with a large number of field magnets without any obvious reason. On the subject of prevention of sparking, he said Mr. Esson had hinted that because his (Mr. Swinburne's) formulæ were calculated, they might be inaccurate, and had therefore given empirical formulæ for maximum output without sparking, taken from the practice of various makers. These, he said, were often misleading, because perhaps none of the machines taken were near their sparking point. His own formulæ were founded on experiment and observation, as well as calculation. As far as efficiency was concerned a small number of poles was advisable, but the limiting output for a two-pole drum was about 100 kilowatts, whereas a four-pole drum would give several hundred kilowatts without sparking. Mr. Esson had, he thought, not dwelt sufficiently on two of the chief advantages of having more than two poles. A four-pole drum armature had very simple end-connections, could be perfectly ventilated, and was easily accessible for repair and inspection. The proper ventilation of large machines he considered to be of the first importance. The coupling up of multipolar armatures was, he said, to be condemned most strongly. Considering a large machine with its armature so coupled, and supposing the bearings to wear a little, he pointed out that a very small eccentricity would decrease the lower air gap and increase the upper gap by 1 per cent.; this means that in an armature having a loss of 2 per cent. the bottom half would do double work, thus involving great waste of power, and heating. This objection, he believed, had not been urged before, but it was very serious in large machines. The armature conductors should therefore be in series, or connected partly in series and partly in parallel, as suggested by Fritsche.

Mr. Housman explained his method of analysing Foucault current and hysteresis losses in dynamo armatures by running them as separately-excited motors without load, and observing the volts and amperes required at different speeds. The results when plotted give an inclined straight line, A B, Fig. 12, from the position of which the Foucault losses may be determined. Friction and hysteresis are not separated in the initial diagram, but the former may be determined by other experiments. The results obtained with various exciting currents show that a certain excitation gives a minimum total loss.

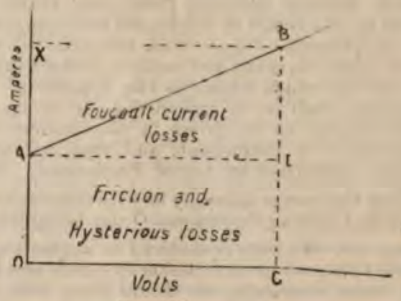

FIG. 12.

Mr. A. T. Snell thought the term "volume of current" would be very useful as a name for a quantity often used by designers. His own experience as regards "volume" and diameter agreed with the formulæ given by the author, and the ratio of the constants, ·048 and ·072 in formulæ (5) and (6), for the output of cylinder and drum armatures, were in the same ratio as the coefficients ·01 and ·015 given by himself about two years ago. He did not agree with Mr. Esson that the output of an armature was independent of the number of poles, for he found that the output could be considerably increased by using four poles instead of two. This he illustrated by the following table, which expresses results obtained from two machines in which the air gaps, speed, and heating were about the same.

Machine.	Diameter of armature.	Volume of current.	Volts.	Amperes.	Watts.
Two-pole	60 cms.	26,660	700	70	50,000
Four-pole	60 ,,	14,700	250	300	75,000

The advantages of four-pole machines generally, he considered due to the air gaps, magnets, and cross-magnetising forces being small, whilst the peripheral velocity for given speed of the shaft could be large. This last was of great importance in direct-driven machines. Their disadvantage was that they usually had a large magnetic density in the iron and air space, but the latter could be obviated by spreading out the polar extremities.

Mr. Miller remarked that in the case of dynamos for the transmission of power, the design was influenced by the voltage of the machine, for there was a limit to the difference of potential that could safely and conveniently be used between commutator sections of ordinary construction. For example, a machine to give 2,000 amperes and 50 volts could best be made multipolar, but not so one for 2,000 volts and 50 amperes. In the latter case it would not be advisable to concentrate the volts in a fourth or sixth of the circumference. On the question of the utility or otherwise of cross-connections in multipolar machines between sections which theoretically should be at the same potential, he said that in practice the evil consequences of various inequalities were minimised thereby. In his opinion, based on experience, the extra expense of cross-connections was well worth incurring, for they produced a distinct diminution in sparking. He also said that Mr. Esson had not even mentioned unipolar machines, presumably because he considered they were worthless. This, he thought, was a mistake. One of the chief faults usually attributed to them—viz., that there was a great fall of volts between no load and full load—did not exist if they were properly designed.

Mr. Crompton said the information contained in the paper would be very useful to engineers. Some speakers had implied that there was no gain in making multipolar machines. This he thought was not correct, for his firm had constructed large four-pole machines quite as efficient as the two-pole type, with an economy of 40 per cent. in material. He then directed attention to the small losses in the armatures of two-pole machines as shown on a diagram illustrating his paper read recently before the Institution of Civil Engineers, and he doubted whether the losses in multipolar machines could be got equally small if the armature circuits were connected in parallel instead of in series. Fritsche windings, as had been pointed out by Mr. Swinburne, could be employed satisfactorily in multipolar armatures. In his opinion no machine lends itself so well to the production of high voltages as the multipolar type.

The discussion was adjourned to the 23rd inst.

LONDON COUNTY COUNCIL.

At the Council meeting on Tuesday the following report of the Highways Committee was brought up:

Electric Lighting—Provisional Orders, 1891.—1. On the 14th instant we reported that we had suggested to the Board of Trade that certain amendments should be made in several electric lighting provisional orders of this session, and we have now to report that a letter has been received from the Board stating that the amendments suggested by us on behalf of the Council have been made in the Westminster order. 2. We have considered the Southwark Electric Lighting Provisional Order, which has been forwarded by the Board of Trade, and have suggested to the Board similar amendments to those with reference to the Wandsworth and other orders reported last week, with the additional suggestion that clause 59A, which relates to the transfer of the undertaking to a company, shall be so amended as to require notice of such intended transfer to be given in the manner required by the standing orders of Parliament, and that no transfer shall take place unless authorised by Act of Parliament. We recommend—

> That the course taken by us with reference to the Southwark Electric Lighting Provisional Order be approved.

Subways.—3. We have considered an application of the National Telephone Company for permission to repair and to partly replace existing cables connecting the Grand Hotel with the Northumberland-avenue subway. We see no objection to this, and we recommend:

> That the National Telephone Company be permitted to carry out the work referred to in the application, under the supervision of the chief engineer of the Council, and upon condition that any damage that may be done to the subway in the execution of the work shall be made good to his satisfaction and at the sole cost of the company.

Notices under Electric Lighting Orders and Acts.—4. We have had before us a letter from the London Electric Supply Corporation, stating, with reference to the requirement attached to the Council's sanction of the works referred to in the company's later notices that each of the street boxes shall be provided with a double cover, that concentric cables are to be used, and that their construction and use are such that shocks are impossible; and the company asks that the requirement may be withdrawn. The chief engineer has reported after inspection of the concentric cables, that where they are used the provision of the second covers may be dispensed with, but that certain conditions with reference to the protection of them from injury should be laid down. He further states as a result of his inspection that there appear to be in some of the company's street boxes some disused cables, and that these may be a source of danger unless removed. We recommend—

> That the London Electric Supply Corporation be informed that in those cases where concentric cables are used, the Council's requirement as to the provision of the second cover to each of the street boxes will not be insisted upon; but that the Council requires that all electric lines other than those in actual use shall be removed from the street boxes; that all pipes or openings from or into the boxes shall be of such shape as to remove all risk of injury to the covering of the cables; that cables crossing the boxes shall be supported from below in the boxes; that all service lines or small cables shall be protected, where leaving the boxes, by an extra lead covering or by wooden stoppers, and shall also have a copper wire of sufficient size carried from the service to the main cable, in good connection with the lead or iron outer casing; that nothing shall be kept in any box but the electric lines in actual use; and that the ends of all mains terminating elsewhere than in a box shall be securely protected by iron caps in addition to any other covering.

5. We have considered a notice, dated 13th April, 1891 (registered No. 194), from the London Electric Supply Corporation, of intention to lay distributing mains in North-row, Green-street, Wood's mews and Norfolk-street, in the parish of St. George, Hanover-square (one plan, D.M., 12/91). These mains will consist of cast-iron pipes with lead-covered concentric cables drawn into them; and the conditions above stated will apply. We recommend—

> That the sanction of the Council be given to the works referred to in the notice (registered No. 194) of the London Electric Supply Corporation, dated 13th April, 1891, on condition that the company do give two days' notice to the Council's chief engineer before commencing the works; that the mains be laid under the footways and be kept 9in. below the under side of the paving wherever it is found practicable to do so; that where the mains cross the carriageways they be kept at the same depth below the concrete or the road material as the case may be; that all pipes or openings from or into the boxes shall be of such shape as to remove all risk of injury to the covering of the cables; that all cables crossing the boxes shall be supported from below in the boxes; that all service lines or small cables shall be protected, where leaving the boxes, by an extra lead covering or by wooden stoppers, and shall also have a copper wire of sufficient size carried from the service to the main cable in good connection with the lead or iron outer casing; and that the ends of all mains terminating elsewhere than in a box shall be securely protected by iron caps in addition to any other covering.

6. We have also to report the receipt of the undermentioned notice, given by the London Electric Supply Corporation, in accordance with the resolution of the Council to accept four days', instead of one month's notice, in respect of the laying of service lines from mains already laid: April 9th, 1891—To 27, New Bond-street, and 1, 3, 4, 17 and 19, Coventry-street.

LEGAL INTELLIGENCE.

ORIENTAL TELEPHONE COMPANY.

The Vendors' Dividend Question.

On Friday, the 18th inst., Mr. Justice Kekewich had to decide as to the construction to be placed upon an agreement to pay dividends to holders of vendors' shares in the above company. The matter was referred to in our report of the company's meeting last week. Sir Horace Davey, Q.C., and Mr. Kerry appeared for Mr. G. P. Ness, a holder of vendors' shares in the company; Mr. Cozens-Hardy, Q.C., and Mr. Theobald representing the company.

Sir Horace Davey said that the agreement was dated Jan. 25, 1881, and stipulated that the vendors were to receive, as holders of certain preferred shares granted to them, a minimum dividend of 6 per cent. for a period of five years, or 30 per cent. in all. One of the clauses in the agreement went on to provide that if, after the expiration of the limited period of five years, the vendors had not received their full 30 per cent. then, that the difference between what they had received and what they ought to have received should be made up out of the surplus profits of the concern. The difficulty that was experienced was with regard to these latter words. The company was incorporated on February 4, 1881, and therefore the period of five years during which 6 per cent. was to be paid on the vendors' preferred shares had expired, the exact date of the expiry of the five years' limit being February 4, 1886. It now turned out that holders of the preferred shares had not received their full dividend of 6 per cent. for the period of five years, and they claimed, under the agreement of January 25, 1881, a sufficient share of the profits as would make up their interest to 30 per cent., insisting that their claim should be in priority to any of the other shareholders.

Mr. Cozens-Hardy, for the company, submitted that the agreement with the vendors was only a limited one, granting them a preference for five years, and five years only. It was, he contended, a charge on the profits of the company for five years, and that period having now expired, the charge was inoperative. At the present time his suggestion was that the vendor shareholders were only entitled to take the share of the profits in the same way as the other shareholders of the company did.

His Lordship thought that Mr. Cozens-Hardy's view of the agreement was the correct one, and gave judgment for the company accordingly.

On the suggestion of **Mr. Cozens-Hardy**, who said that the company would not ask for costs, no order was made in that direction.

FAREHAM LOCAL BOARD AND FAREHAM ELECTRIC LIGHT COMPANY v. SMITH.

Overhead Wires.

This case came before Mr. Justice Chitty in the Chancery Division of the High Court of Justice on Thursday, the 16th inst. It was a motion, treated as the trial of the action, by the above Local Board and the above electric light company for an injunction to restrain the defendant from removing, cutting, or otherwise interfering with the electric wires and apparatus placed in Osborne-road, Fareham, for lighting the said road and other public places in the district of the Local Board. It appeared that the Local Board had entered into a contract with the electric light company to light the town of Fareham with electric light. No license from the Board of Trade or provisional order had been obtained by the company under the Electric Lighting Acts, 1882 and 1888, but they erected their poles and overhead wires under a license from the Local Board. The defendant was owner in fee in possession of land having a frontage of 120ft. to Osborne-road, which was a highway repairable by the inhabitants of Fareham at large, and vested in the Local Board. The defendant had sent in to the Local Board a copy of plans of intended buildings on his land, and he alleged that the poles and wires which were erected on his side of the road, and rose to a height of some 16ft. to 19ft. above the surface of the road, would interfere with his intended buildings. The windows to the buildings comprised bay windows, looking immediately over the road, and it was alleged by the defendant that one of the wires would come into contact with the bay windows if his plans were to be carried out as contemplated. The defendant, as owner of the land adjacent to the highway, claimed to be entitled to the subsoil of the adjoining half of the highway, and to be entitled to treat the plaintiffs as trespassers.

Mr. Whitehorne, Q.C., and Mr. A. Glen appeared for the plaintiffs; Mr. Farwell, Q.C., and Mr. Bovill Smith (and at former hearings Mr. Romer, Q.C., now Mr. Justice Romer, and more recently Mr. Henn Collins, Q.C., now Mr. Justice Henn Collins) appeared for the defendant.

Mr. Justice Chitty said that the defendant claimed to have a right to cut the wires of the electric light company because he was the owner of the soil of half of the road, subject only to any statutory rights vested in the Local Board. The defendant said that inasmuch as the subsoil below such part of the surface as was included in the term "street," as used in the Public Health Act of 1875, was vested in him, therefore his right as proprietor of the subsoil carried with it the property in the air, which was above the surface, subject only to such rights as the Local Board also had in the air above the surface. That was the main ground on which the defendant justified his threat to cut the wires. The conveyance under which the defendant derived his title to the property did not specifically pass the half of the road, but the defendant's right thereto depended on the application to the case that where a close in a conveyance was described as bounded by a public highway, half of the soil of the highway belonged to the grantee, unless the legal presumption to that effect was rebutted. Whether the circumstances of the present case were sufficient to constitute a rebuttal was a question on which, in his opinion, it was unnecessary to come to a decision. He would, however, assume that the point was in favour of the defendant, and that he was right in his claim to the soil of the road. At the time when the conveyance was made the road was dedicated to the public, and the Local Board had taken over the road, and it was a public highway for all purposes. The road was, under the Public Health Act of 1875, a street vested in the Local Board, and, according to the authorities, what was comprised in the term street was not merely the surface of the road, but the soil below the surface to such a depth beneath as was required for the purpose of enabling the local authority to execute its statutory powers and to perform its statutory duties. The depth to which the Board's statutory right extended below the street was not defined by the Act of Parliament, but it was ascertainable. Another way of stating the same proposition was to say that there vested in the Local Board the area of user of the street below its surface. The exact depth to which such user might extend obviously differed in different cases—for instance, the depth of a properly-constructed sewer would in some roads have to be lower than in others. The proposition was founded on the decisions given in the cases of Coverdale *v.* Charlton (L.R. 4, Q.B., 105) and Wandsworth Board *v.* United Telephone Company (L.R. 13, Q.B., 905) with respect to the rights of local boards under the surface. The latter case also, in his opinion, showed that a similar and corresponding proposition might be correctly stated with reference to the zone above the surface of the road. The local authority was entitled to take so much of the zone above as was required for the due execution of its powers and the due performance of its duties. To express the matter shortly, it was the area of user which showed what was vested, and the street comprised the zone. The local board had a proprietary right in the zone above the surface, or, at any rate, had a possession of so much above and so much below as fell within the objects of the Act. In the present case the Local Board had contracted with the plaintiff company for the supply of electric light for public purposes. In pursuance of such contract, and, as the plaintiffs contended, by virtue of the Local Board's statutory right, posts and wires had been erected. The defendant did not complain of the work done being unnecessary for its purposes or beyond what was justified to carry out its object. He did not say, for instance, that the height of the posts or wires was unusual and excessive. It appeared to his Lordship, therefore, that the defendant must fail unless he could show that what had been done by the plaintiffs (and for this purpose it was not necessary to distinguish between either the plaintiff Board or the plaintiff company) was a trespass. What the defendant must say was that the plaintiffs had invaded his proprietary rights, and that he was, therefore, entitled to treat the plaintiffs as trespassers and to destroy their works which were intended to be permanent. The question, therefore, arose whether the works were within the area of user of the street. He thought that they were within that zone which the statute had vested in the plaintiff Board. That being so, the defendant was not entitled to assume the position of Attorney-General and interfere. The plaintiff company had argued that they had only done what they had the right to do by virtue of the powers conferred on them by the plaintiff Board. It appeared that pending the hearing of the present action the company had been indicted for a public nuisance, and the trial coming on in March last at the Hants Assizes, the jury, by the direction of Lord Chief Justice Coleridge, acquitted the defendants. The result of what Lord Coleridge held was, as appeared from a transcript of the judgment, that the company was protected by the authority of the Local Board, which was acting within its authority, and that the law justified the company. Lord Coleridge rested his decision in his direction to the jury on section 161 of the Public Health Act, 1875, which said that the authority might contract with any person for the supply of gas or other means of lighting the streets in their district, and might provide such lamps and other materials and apparatus as they might think necessary for lighting the same. Lord Coleridge held that "other means of lighting" included other means of lighting than by gas—*e.g.*, by electricity. He respectfully concurred in what the Lord Chief Justice held. The company's position was the same as if the Local Board itself had put up the posts and wires. The Board contracted with the company that the company should do the work and provide the posts and other apparatus, and the company was not to be at liberty to remove them for a term of years still unexpired. It appeared to him that what was being done fell within the words of section 161. So far as he was aware a local board had no power to themselves manufacture electric light, and what was done was that they bought or hired. In the present case the Board had taken the latter course. The posts and wires, therefore, were now standing on and hanging over the road by virtue of a statutory authority conferred on the Board. Mr. Henn Collins had delivered a concise and able argument with reference to the second and third paragraphs of section 161, which spoke of gas undertakings by the urban authority, upon which he founded the proposition that the Board was acting *ultra vires* when engaged in providing apparatus for lighting that was not lighting by gas. He (Mr. Justice Chitty), however, was of opinion that the second and third paragraphs did not affect the statutory power of a Board to supply light by other means than gas under the general words of the first paragraph, and that in that respect they were not a modification of the general powers of that paragraph, and it appeared to him that the second and third paragraphs were inserted because of the well-known course of legislation with respect to gas companies, which, to use terms which had been often applied to them, had a regulated monopoly in their particular districts, and the meaning of subsections 2 and 3 was that the urban authority should not invade that monopoly when conferred by statute. He had referred to the argument in the second and third paragraphs, because, so far as he was aware, the point had not been raised at the trial before Lord Coleridge. The result was that thus far he was in favour of the plaintiffs. But another point had been raised on behalf of the defendant; and that was that there was a public nuisance inflicting special damage on the defendant. If, however, the facts were as he had held them to be, that the acts complained of were not a public nuisance, that part of the case fell through. The defendant said that he desired to build on his ground, and that the posts and wires interfered with his proposed plans as sent in to the Board. At the bottom of this action there had unquestionably been a contest between electric lighting on the one hand and gas lighting on the other. He did not propose to give any opinion as to whether the plans were sent in by the defendant to embarrass the Board. It, however, seemed to him that the possibility of the posts and wires interfering with the amenities properly enjoyable by the defendant, or with his convenience, was not a contingency which would justify the Court in refusing an injunction at the present time. Moreover, the point was one which might be provided for by means of compensation, under section 308 of the Act. He therefore granted an injunction, as asked, with liberty to both parties to apply, so that if any unforeseen circumstance should arise the defendant might apply to modify the injunction. The costs would follow the event.—*The Times.*

JABLOCHKOFF'S PATENT.

This was a motion of the Electrical Engineering Corporation, Limited, before the Judicial Committee of the Privy Council, on Wednesday, asking that the requirements as to advertisements and notices in reference to a petition for the confirmation of this patent should be dispensed with or modified.

Mr. Moulton, Q.C., and Mr. Roger Wallace appeared in support of the motion; the Attorney-General and Mr. Sutton for the Crown.

Mr. Moulton said that on the last occasion the hearing was adjourned in order that they might make such advertisements as they could, and present such petition for confirmation as they saw fit. On examining into the dates they had discovered that the ordinary period for confirmation would not expire until after the end of the patent, and, therefore, after considering everything, they came to the conclusion that the only course would be to apply to their lordships to remit the ordinary rules with regard to advertisements and to allow them to give such advertisements as their lordships thought fit and proper in the circumstances, so that both petitions (for confirmation and prolongation of the patent) should come on for hearing before May 22, on which day the period of the patent expired. Before presenting the petition for prolongation they gave notice to all persons who had given notice of appearance and to all persons who had a statutable right to notice. He s
that the requirements as to advertisements and noti
to the petition for confirmation of a patent shou
with or modified.

The **Attorney-General** said he had nothing in the least to say with reference to any relaxation of the rule which their lordships thought fit. It would be his duty to contend on behalf of the public when the application came on for hearing that it was not a case in which the patent should be confirmed; but he was not dealing with that now. He submitted that their lordships should be satisfied that sufficient notice was given, and he suggested that advertisements should be inserted in the *London Gazette*, two London newspapers, and electrical newspapers.

Lord Watson said their lordships were of opinion that this was a case in which the rule with respect to notice might be relaxed without detriment to the public. They would fix Wednesday, May 13th next, for the hearing of both petitions. They would dispense with the provisions of rule 1, and direct that the petitioner give due notice of the hearing of the petition for confirmation in the *London Gazette*, the *Times*, the *Electrical Review*, the *Electrician*, *Industries*, and *Engineering*.

LONDON ELECTRIC SUPPLY CORPORATION, LIMITED, v. FRIESE GREENE.

This case came before Mr. Justice Denman and a special jury on Wednesday. It was an action to recover £64, amount alleged to be due for the supply of electric current to the defendant's premises, 92, Piccadilly. The plaintiff's case was that in December, 1887, they agreed to supply the defendant's photographic studio with an electric current to enable the defendant to take photographs by the electric light; that in pursuance of that agreement the electric current was laid on in April, 1888, and was continued to be used by the defendant until June, 1889, when it was cut off, owing to the defendant refusing to pay for the supply, for which the present action was brought. The defendant, while admitting that he had been supplied with the amount of electric current charged for, counterclaimed for damages, which he alleged were caused by the plaintiffs failing to carry out their agreement with him for the supply of an electric current sufficient for the purpose of taking photographs. His case was that the agreement with the plaintiffs, which was in writing, was for the supply of an electric current for a 4,000-c.p. lamp and a 1,000-c.p. lamp, whereas the current supplied was not of the power provided for by the agreement, was not supplied during the agreed hours, was unsteady and intermittent and frequently failed, or was cut off by the plaintiffs, and was not supplied until April, 1888; that he had been put to great expense in fitting up his studio for the supply of current; that in consequence of the weak, unsteady, and intermittent supply of the current he was unable to produce satisfactory photographs, and his takings dropped from £80 to £20; that the studio was useless for photographic purposes in the absence of the electric light, and he lost the rent and money expended upon it.

The **Defendant** was called and gave evidence in support of his counterclaim, as above stated. Former customers of the defendant's were also called, and stated that they were dissatisfied with their photographs taken under the electric light by the defendant, and in consequence they had ceased to patronise him. An electrical engineer was also called, and stated that the lamp fitted up in the studio was one of 4,000 c.p., whereas the current supplied was of only 1,500 c.p., which was the reason of the flickering and weak light.

The learned **Judge**, in summing up, said that, subject to any right of counterclaim, the plaintiffs would be entitled to £64, and the sum claimed. It would be competent for the defendant to make out a counterclaim in certain ways. Although the defendant had used the current, still, if the plaintiffs had violated any contract with him, the plaintiffs might have to pay him damages. The defendant rested his counterclaim, first, on the delay. There was no time fixed for the commencement of the supply, and the defendant would be entitled to damages for the delay if the supply was not made within a reasonable time. But the jury must look at the conduct of both parties and the nature of the complaints made at the time. The next complaint was that the supply was so fitful and bad that the defendant lost customers and suffered damage to the extent of £2,000. The defendant took the premises early in 1887. For some time there had been a certain business there, but no photography was carried on there during the whole of 1887. Customers were sent to Bond-street if they wanted to be photographed. In December, 1887, the bargain was made with the plaintiffs to supply the electrical current. The letters would show whether it was a genuine counterclaim. On January 6, 1888, the defendant wrote to have the current laid on at his premises. On January 16 the secretary of the company wrote that the company would name no definite time for laying on the current, as there was some difficulty in reaching him. Down to March 12 the correspondence went on, and the defendant never said he had given up owing to the delay. The question was whether the defendant at that date had waived his claim for damages for delay. Did not both parties consider it as rather doubtful when the connection could be made? In October, 1889, after four applications for payment, the plaintiffs wrote that they would have to cut off the current unless they were paid, to which letter there was no reply. The matter was then put in the hands of the plaintiffs' solicitors. At the date this demand was made upon the defendant he did not write making the same complaints as appeared in the counterclaim. The correspondence looked like that of a man who did not think he had any rights for delay or anything of that sort.

The jury returned a verdict for the plaintiffs for £64.

Mr. Stephen Lynch was for the plaintiffs; Mr. Barnard Lailey for the defendant.

COMPANIES' MEETINGS.

EASTERN EXTENSION TELEGRAPH COMPANY.

The thirty-fifth general meeting of this Company was held at Winchester House on Wednesday, Sir John Pender, K.C.M.G., chairman, presiding.

The **Chairman** said the gross receipts for the past half-year amounted to £279,095, against £264,103 for the corresponding period of 1889, showing an increase of £14,992. This was partly due to profit on exchange during the sudden but temporary rise in the value of silver, and partly to increased traffic with Australia. The working expenses had been £74,090, against £73,498 for the corresponding half-year of 1889, or an increase of £592. The net revenue was £166,807, against £146,144 in 1889, or an increase of £20,663. This was explained by the additional revenue already referred to, and the disappearance from the accounts for the past half-year of £6,500 charged in former accounts for the interest and sinking fund in connection with the 5 per cent. Manilla debentures paid off last year. The net saving on this account was £5,000 a year. The usual interim dividends were distributed during the year, making, with the dividend proposed to be paid the following day, a total payment of 5 per cent. for the year, which, with the proposed bonus of 4s. per share, would make a total distribution during 1890 of 7 per cent. After taking from revenue £100,000 on account of the Madras-Penang duplicate cable, and £1,120 for a new land line at Banjoewangie, and additions to staff quarters there, there remained a balance of £25,007 which had been carried to general reserve fund, which now stood at £495,239. Nearly a million sterling had been taken from reserve and revenue for cable renewals and duplications since the Company was formed. The past was the best year the Company had ever had, so far as revenue was concerned, the gross revenue being £533,951, or £27,450 in excess of the best previous year—namely, 1885—when the tariffs were in force, which were subsequently reduced at the Berlin conference. An official quotation of their recently-issued 4 per cent. debenture stock had been obtained, and it now stood at from five to seven premium. By the conversion of their 6 per cent. stock into 4 per cent. an annual saving of £6,400 had been effected, making, with the saving of £5,000 already referred to, a permanent saving of £11,400 per annum. Referring to the reduction of rates to Australia, the Chairman said that the agreement was made with Victoria, New South Wales, South Australia, West Australia and Tasmania, who guaranteed the Company against one-half of the risk of any loss, the Company taking the other half. The arrangement was for a tentative period of one year, to be extended if found to work satisfactorily. Consequently the continuance of the reduced rates depended upon the telegraphing public giving the experiment their support and making it a success. It was hoped that Queensland and New Zealand would have taken part in the reduction, but after considerable negotiation between the various Governments these colonies declined to do so, and the tariff to them would therefore remain unchanged. Since the report had been issued an agreement had been formally concluded between the Company and the Indo-European Department of Her Majesty's Government, by which the risks of the reduction in rates would be shared between the parties according to their respective interest in the Australian traffic. The maximum liability, if no increase of traffic resulted from the reduction, would be £131,810, of which the contracting colonies' share would be £64,905, this Company's portion being £42,500, while the balance of £23,405 would be divided between the three other contracting parties. Since the close of the year the Telegraph Construction and Maintenance Company had successfully completed their contract for the duplication of the Madras-Penang cable, and the Eastern Company's new cable between Aden and Bombay having also been laid the service was now in a thoroughly efficient condition. The sum of £100,000 had been paid out of revenue towards the cost of duplicating the above cable. The total length of their cables was now 15,700 nautical miles. He thought the report he had read to them would be very difficult to beat. If their new departure with regard to Australia was successful, no doubt it would be extended elsewhere. He believed they would recoup themselves the reduction in a very short period of time. They had been working at the question of the reduction for six years. Getting good guarantees of 3 per cent. upon the whole of the Company's capital would materially improve the value of their stock and give the investing public confidence in it. The Great Northern Telegraph Company and their Company continued to work together satisfactorily. He then moved the adoption of the report and accounts, which was seconded by the **Marquis of Tweeddale**, and carried unanimously.

Further resolutions re-electing the retiring Directors and Auditors were also duly carried.

SOUTH OF ENGLAND TELEPHONE COMPANY.

A meeting of preference shareholders called by Mr. T. A. Welton, liquidator of this Company, was held at Winchester House on Monday. Mr. Welton took the chair and explained to the solitary shareholder present that the meeting was called to give preference shareholders the option of taking debenture stock in the National Telephone Company in exchange for their shares, or cash. Of the £70,000 to be issued, shareholders had already intimated their wish to receive debenture stock to the amount of nearly two-thirds of that sum. The stock was quoted at 103. Mr. Welton said he should report the result of the meeting to the other preference shareholders who had not attended, or stated their intentions. Those who did not answer would be offered cash.

COMPANIES' REPORTS.

REUTERS.

The report of the Directors of Reuter's Telegram Company, Limited, states that the net profits for the year ending December 31 last, after payment of Directors' remuneration, current expenses, and deducting rebate on unexpired subscriptions, amount to £4,594. 7s., including £113. 14s. 6d. brought forward from the last account. An interim dividend of 4s. per share was paid in October last, and the Directors now recommend a further dividend of 4s. per share, making a total distribution for the year of 5 per cent. This will absorb £3,691. 2s. 6d., and leave a balance of £903. 4s. 6d. to be carried forward.

METROPOLITAN ELECTRIC SUPPLY COMPANY, LIMITED.

Directors: Sir John Pender, K.C.M.G., chairman; Sir George Elliot, Bart., M.P.; Sir Robert N. Fowler, Bart., M.P., Alderman; Admiral Sir George H. Richards, K.C.B., F.R.S.; Sir James Anderson; J. Spencer Balfour, Esq., M.P.; J. E. H. Gordon, Esq.; J. C. Parkinson, Esq.; J. Denison Pender, Esq.; John B. Verity, Esq.; H. Granville Wright, Esq. Secretary: E. Cunliffe-Owen, Esq., C.M.G. Manager: E. S. Claremont, Esq. Chief engineer: Frank Bailey, Esq., A.M.I.C.E. Consulting engineers: Sir William Thomson, F.R.S.; Dr. John Hopkinson, F.R.S.; Prof. George Forbes, F.R.S.; J. E. H. Gordon, Esq., M.I.C.E.

Report of Directors to be presented to the shareholders at the fourth ordinary general meeting to be held at Winchester House, Old Broad-street, E.C., on Wednesday, 29th inst., at 11.30 a.m.:

The Directors have the pleasure to submit to the shareholders a statement of the Company's accounts for the period commencing the 1st October, 1889, and ending the 31st December, 1890. The form in which this statement is presented is that prescribed by the Board of Trade under the provisions of the Electric Lighting Acts of 1882 and 1888. It should be remembered that the period under review commences one month after the date when parliamentary powers were granted, and comprises the time during which the greater portion of the Company's works of construction were being carried out. The growth of business may best be realised by comparing the gross revenue for the last three months of 1889, which was £2,866. 15s. 7d., with the corresponding period in 1890, when it amounted to £10,726. 19s. The number of lamp connections which, at the close of 1889, were 14,000, amounted at the close of 1890 to 48,000. This number has been since increased to 58,000, and the demand for the light in the Company's districts is steadily on the increase. Having regard to the fact that the period under review has been mainly one of construction, it is a matter for congratulation that the Company's income, which was to a great extent the result of the last three months' working, has resulted in a profit, which, though a small one, gives the strongest grounds for confidence in the immediate future. The earnings of the first three months of the present year are so encouraging that the Directors have decided to make an interim distribution of 2s. per share, which will be paid on May 1 next. The Company's stations at Whitehall, Sardinia-street, Rathbone-place, and Manchester-square, are now completed, and their working has so far given great satisfaction to the Board. It is confidently anticipated that the new station for the Paddington district, the machinery for which is in a forward state, will be at work in time for next winter's lighting. These stations, with the mains and other necessary plant, will about absorb the Company's present issue of capital, but as the demand for electric lighting increases the Directors will be prepared to recommend steps being taken to meet it. In accordance with the articles of association the following Directors—viz., Alderman Sir Robert N. Fowler, Bart., M.P., Mr. J. E. H. Gordon, and Mr. J. C. Parkinson, retire from the Board. Sir Robert Fowler and Mr. Parkinson being eligible, offer themselves for re-election. The Directors regret that Mr. Gordon, owing to his increasing business as a consulting engineer, has considered it advisable not to seek re-election. He will, however, continue to act as one of the Company's consulting engineers. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., retire, and offer themselves for re-election.

REVENUE ACCOUNT FOR THE 15 MONTHS FROM 1ST OCTOBER TO 31ST DECEMBER LAST.

A.—To Generation of Electricity.

		£ s. d.	£ s. d.
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works		12,205 12 5	
Oil, waste, water, and engine-room stores		2,190 5 4	
Proportion of salaries of engineers, superintendents, and officers		1,501 1 8	
Wages and allowances at generating stations		3,525 5 4	
Repairs and maintenance, as follows;			
Buildings	59 2 11		
Engines, boilers	521 10 2		
Dynamos and exciters transformers, motors, etc.	217 13 10		
Other machinery, instruments and tools	606 4 2		
Accumulators and accessories	214 1 11		
		1,618 13 0	
			21,040 17 9

B.—To Distribution of Electricity.

Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same	9 10 0	
Pole rents and wayleaves	51 4 11	
		60 14 11

C.—To Proportion of Rents, Rates and Taxes.

Rents payable and rates and taxes...	2,905 19 10

D.—To Proportion of Management Expenses.

Directors' remuneration	900 0 0	
Salaries of management, secretary, engineers, accountants, clerks, and messengers	1,600 0 0	
Wages of meter readers	11 11 0	
Stationery, printing, and agreements	115 0 0	
General establishment charges	362 18 8	
Auditor	60 0 0	
		3,049 9 8

E.—To Proportion of Law and Parliamentary Charges.

Law expenses	20 0 0

F.—To Special Charges.

Insurances	333 6 11
Total expenditure	27,410 9 1
Balance carried to net revenue	136 5 5
	£27,546 14 6

Cr.	£ s. d.	£ s. d.
Sale of current per meter at 7¼d. per B.T.U.	10,327 15 11	
Sale under contracts	15,954 16 11	
		26,282 12 10
Rental of meters and other apparatus on consumers' premises		1,028 11 8
Rents receivable		135 9 6
Transfer fees		100 0 6
		£27,546 14 6

NET REVENUE ACCOUNT TO 31ST DECEMBER, 1890.

Dr.	£ s. d.
Bank charges and commission	23 0 11
Allowances to electric light customers	704 4 7
Bad debts	159 10 2
Balance applicable to dividend on ordinary stock or shares	461 10 2
	£1,348 5 10

Cr.	£ s. d.
Balance brought from revenue account (No. IV.)	136 5 5
Interest on money at deposit	654 9 3
Discounts	557 11 2
	£1,348 5 10

GENERAL BALANCE-SHEET, 31ST DECEMBER, 1890.

Dr.	£ s. d.
Capital account—Amount received as per account No. III.	368,016 9 0
Temporary loans	25,000 0 0
To sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc.	24,014 3 1
Sundry creditors on open accounts	996 9 7
Net revenue account—Balance at credit thereof	461 10 2
	£418,488 11 10

Cr.		£ s. d.
Capital account—Amount expended for works as per account No. III.		363,886 3 6
Stores on hand:	£ s. d.	
Coal	275 12 6	
Oils, waste, etc.	130 8 4	
General	6,971 15 7	
		7,377 16 5
Sundry debtors for amounts paid on account of contracts in course of completion		3,865 13 9
Preliminary expenses		5,052 10 4
Sundry debtors for current supplied		10,394 5 10
Other debtors		254 19 5
Deposits (provisional orders, vestries, etc.)		21,814 9 10
Cash at bankers:	£ s. d.	
Messrs. Prescott, Dimsdale, & Co.	2,322 4 10	
The Royal Bank of Scotland	3,508 12 3	
		5,830 17 1
Cash in hand		11 15 8
		£418,488 11 10

NEW COMPANIES REGISTERED.

Carbon Electric, Limited.—Registered by Robinson and Stanward, 19, Eastcheap, E.C., with a capital of £20,000 in £5 shares. Object: to carry on the business of manufacturers of carbon rods and plates for electrical purposes, in accordance with an agreement made March 7 between Henry J. Chappell of the one part and G. B. Cook of the other part. There shall not be less than three nor more than five Directors. The first are Henry James Chappell, Edward J. Conlon, James C. Cole, and C. H. W. Biggs. Qualification, £125. Remuneration: Chairman, £150; other directors, £100 each.

Collier Audible Telephone Syndicate, Limited.—Registered by Leslie, Antill, and Arnold, 1, Gresham-buildings, Basinghall-street, with a capital of £9,000 in £100 shares. Object: to acquire and develop the inventions of Arthur T. Collier in respect of improved telephonic receivers and transmitters. Arthur T. Collier is appointed managing director, with a remuneration of £400.

International Electric Syndicate, Limited.—Registered by Sydney James, 60, Lincoln's-inn-fields, with a capital of £12,000 in £10 shares. Object: to acquire certain patents relating to electrical accumulators, etc., and to develop the same. Registered without articles of association.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for last week were £5,750.

Western and Brazilian Telegraph Company.—The receipts of this Company for last week were £4,640.

West Coast of America Telegraph Company.—The offices of this Company have been removed to 120, Cannon-street, E.C.

City and South London Railway.—The receipts for the week ending April 18th were £816, as compared with £827 for the week ending April 11th.

Metropolitan Electric Supply Company.—An interim dividend of 2s. per share, tax free, for the quarter ended March 31, payable on May 1, is announced.

West India and Panama Telegraph Company.—The receipts for the half-month ended April 15 were £3,613, as against £3,592. The December receipts, estimated at £5,102, realised £5,175.

London Platino-Brazilian Telegraph Company. — After placing £6,000 to the reserve fund, a dividend of 5s. per share, tax free, is recommended, making a distribution of 4½ per cent. per annum for the year 1890.

Dividends.—The West India and Panama Telegraph Company recommend a dividend of 6s. for the six months to December 31 on the first preference, 34s. 6d. on the second preference (*i.e.*, 28s. 6d. balance of arrears and 6s. dividend for the six months to December 31), and 9d. per share on the ordinary shares, carrying forward £668.

Eastern Telegraph Company.—It is announced that, in view of the reduction of the telegraph rates to Australia to come into operation on the 1st May next, and to meet all requirements that may arise in connection with the anticipated increase of traffic, two new cables of great carrying capacity have been laid between Suez and Aden, and Aden and Bombay, thus affording increased speed and security in the transmission of traffic over its lines.

PROVISIONAL PATENTS, 1891.

APRIL 13.

6276. **Electric locking devices for the gear wheels of motors of electric cars (or carriages).** George W. Blanchard, 35, Southampton-buildings, London. (Complete specification.)

6292. **An improved form of insulator for use with electrical currents.** Herbert Woodville Miller, 2, York-mansions, Earl's Court, London. (Complete specification.)

6298. **Improvements of armatures of dynamo-electric machines and motors.** Josef Wodicka, 5, Findon-terrace, Crouch Hill.

6318. **An improvement relating to medico-electric batteries.** Noah Mitchell, 166, Fleet-street, London.

APRIL 14.

6347. **Improvements in alternating-current transformers.** George Thomas Tugwell and Edward Albert Mitchell, 25, Montpelier-street, Brighton.

6372. **Improvements in electric time calls.** Richard Varley, jun., 33, Chancery-lane, London.

6378. **Improvements in and relating to electric motors.** Charles J. Van Depoele, 45, Southampton-buildings, London. (Complete specification.)

6397. **Improvements in phonophoric telegraphy.** Charles Langdon-Davies, 24, Southampton-buildings, London.

6402. **Improvements in microphonic or telephonic transmitters.** Arthur Thomas Collier, 45, Southampton-buildings, London.

APRIL 15.

6455. **An improved method for fixing metal parts to non-combustible electrical switches, cut-outs, connectors, or similar devices.** Charles Rivington Shill, 70, Oakhurst-grove, East Dulwich-road, London.

6474. **Improvements in materials or compounds to be used as substitutes for wood, vulcanite, ebonite, and the like, in the manufacture of articles such as electrical insulators, cells for electrical accumulators, boxes, door handles, toys, and other articles of the like kind.** Walter Gritten and Joseph Lang, 35, Southampton-buildings, London.

6485. **Improvements in dynamo-electric and electro-dynamic machines.** Alphonse Isidore Gravier, 191, Fleet-street, London.

6489. **A combined ceiling switch, cut-out, and ceiling rose for electric incandescent lamps.** William Robert Pryke, 166, Fleet-street, London.

6492. **An improved holder and shade for electric glow lamps.** Charles Barter, 433, Strand, London.

APRIL 16.

6517. **Improvements in electric light switches.** Charles Mark Dorman and Reginald Arthur Smith, 24, Brazenose-street, Manchester.

6559. **Improved electric bell push.** John Malcolm Nicol, 1, Quality-court, London.

APRIL 17.

6614. **Taylor's patent automatic electric bell signals for the prevention of collisions and accidents in foggy weather, or through engine drivers running past danger signals.** Henry Ramsay Taylor, 50, George-street, Edinburgh.

6633. **Improvements in or relating to electric meters.** Francis Teague, 433, Strand, London.

6655. **Improvements in supports for telegraph insulators.** John Crisp Fuller and George Fuller, 33, Chancery-lane, London.

6660. **Improvements in the method of distribution of electrical energy and in apparatus incidental thereto.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

APRIL 18.

6677. **Improvements in the construction of magneto-electro medical apparatus.** Desire Thomas Piot, 71, Bolsover-street, Euston-road, London.

6730. **Improvements in dynamo-electric machines.** William Morris Mordey, 46, Lincoln's-inn-fields, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1881.

4034. **Magneto-electric machines, etc.** Jensen (Edison). (Second edition.) 8d.

1886.

10765. **Secondary generators.** Lowrie and Hall. (Second edition.) 11d.

1890.

4791. **Measuring electrical currents.** Douglas. 8d.

5540. **Electrical measures.** Higgins. 8d.

5916. **Electric bells.** Bonné. (Actien Gesellschaft Mix and Genest). 6d.

5926. **Electrical conductors, etc.** Pitt (Atherton). 8d.

6266. **Electrolysis.** Marx. 8d.

6631. **Electrical curative apparatus.** Aird. 8d.

6667. **Electric meter.** Frager. 8d.

7456. **Applying electricity to produce water pressure, etc.** De Brouchere and Anspach. 8d.

7511. **Brush for dynamos, etc.** Immisch. 8d.

7513. **Secondary batteries.** Wise (Schoop). 6d.

8031. **Printing telegraphs.** Radcliffe. 8d.

8116. **Electrical switches.** Binswanger and Franke. 6d.

8153. **Electric accumulators.** Holmes. 6d.

8174. **Electrical transmitting apparatus.** Richard, J. and F. 8d.

8477. **Electric switches.** Beevor. 8d.

8854. **Measuring electrical energy.** Desruelles and Chauvin. 8d.

1891.

1007. **Separating ores, etc., by electricity.** Ferraris. 6d.

1279. **Electric railway signals.** Wiley and others. 8d.

1425. **Storage batteries.** Boult (Roberts). 8d.

3336. **Electrically welding, etc.** Lake (Lemp and another.). 8d.

3495. **Electric switch.** Dorman and Smith. 6d.

3609. **Electricity meters.** Hartmann and Braun. 6d.

3673. **Electric arc lamps.** Siebold. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¼
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Mexico.—It is intended to construct an electric railway between the city of Mexico and Chapultepec.

Paris Concessions.—The Paris Municipality, on Wednesday, renewed for 10 years the contracts for the electric lighting of the Boulevards.

Paris.—The central station of the Secteur de la Place Clichy was opened on Tuesday in the presence of a large number of official representatives.

Copper Wire for Paris.—Tenders will be awarded at Paris (103, Rue de Grenelle) on May 6 for 180,000 kilogrammes of copper wire of high conductivity.

Appointment.—The Secretary of State has appointed Mr. A. A. Campbell Swinton to be permanent consulting electrical engineer to the Metropolitan Police.

Corsican Cable.—A second cable is to be laid between Corsica and the mainland. It will be laid from Corsica to the Iles d'Hyères, and thence overland to Marseilles.

Electric Boats in Paris.—The *Bulletin International* announces that an enterprise for the use of electric boats on the Seine is being considered at the present moment.

Electrometallurgy.—A limited company, with a capital of £100,000, has been registered under the name of the British Electrolytic Syndicate to carry on electric metallurgy.

Spain.—The use of electric light is extending in Spain. There are now 6,000 lamps in Valencia, 1,000 in Gijon, 800 at Albacte, 700 at Cuenca, 550 at Pampeluna, and 400 at Talavera.

Redruth.—In about a fortnight the electric light will illuminate Redruth, certain enterprising business men having contracted with Mr. Williams, electrical engineer, London, for the supply.

Bremen. — The tramway company of Bremen has decided to replace all its horses by electric traction, on the Thomson-Houston system, which has given such excellent economical results during last year.

Harrogate.—The Bill confirming the provisional order relating to the electric lighting of the town of Harrogate by the Corporation passed the Examiner on Standing Orders of the House of Commons on Monday

Dewsbury.—On Monday the Confirmation Bill of the provisional order placing the electric lighting of the town of Dewsbury in the hands of the Corporation passed the standing orders of the House of Commons.

Brush Company.—The Duke of Marlborough has accepted the position of chairman of the Brush Electrical Engineering Company, Limited, in succession to Lord Thurlow, who has resigned his seat at the Board.

Brussels Tramways.—Brussels has not finished with its trials of electric traction, if we are to believe the item published in the French papers, that a semi-circular electric railway is shortly to be installed in the Bois de la Cambre at Brussels.

Teeth Planing Machine.—M. Herman Michaelis, of Chemnitz, has brought out a planing machine for making tooth gearing which forms the tooth direct out of the solid by a specially shaped cutter. This tool should be useful in engineering shops.

Liquidation.—At an extraordinary general meeting of the Electrical Engineering Corporation, Limited, held on the 23rd inst., it was resolved to wind up the company voluntarily, and Mr. Fras. W. Pixley, of 24, Moorgate-street, was appointed liquidator.

Heckmondwike.—The provisional order of the Board of Trade has entrusted the electric lighting of the town to the Local Board, and on Monday the Examiner on Standing Orders of the House of Commons passed unopposed a Bill to confirm that provisional order.

Exhibition at Palermo.—The Palermo Exhibition, which will be open from November 1, 1891, to May 31, 1892, will have an international section for engines and for machinery for minor industries. Applications for space to exhibit in this section should be made on or before May 15 next.

Electric Tramways.—A sign of the times is seen in the registration of the London Electrical Tramways Company, having a capital of £150,000, with the object of buying up the tramways of the North London Tramways Company, and to carry on, extend, and develop the same electrically.

Telephoning to Marseilles.—It is stated that the telephone between London and Marseilles is expected to be in working order at the beginning of next month, and to be open to the public shortly after. The tariff has not yet been fixed. Communication between London and Bordeaux is now only a question of time.

Police and Telephones.—From a recent incident it would seem desirable to instruct policemen in the use of the telephone. Mr. Webb, of the Devonport County Council, mentioned the case of a young constable who, not understanding its use, asked him to send a message. A delay of this kind might be serious.

Ferry Boat Lighting.—The Bridges Committee of the London County Council, with a view of effecting an economy in and the proper working of the electric light of the ferry boats, have given directions for the dynamo engines to be worked on the non-condensing principle. The cost of carrying out the work will not exceed £24.

O.S.A. Papers.—A paper will be read on "Researches in Electromagnetic Induction," by Mr. Ernest B. Vignoles, on May 13th, at 8 p.m., at the Central Institution, Exhibition-road, S.W. A paper will be read on "Recent Advances in Optics," by Prof. S. P. Thompson, B.A., D.Sc. The date and place of meeting will shortly be announced.

Institution Papers.—Before the Institution of Electrical Engineers, on Thursday, May 7th, papers will be read (1) "On some Effects of Alternating Current Flow in Conductors having Capacity and Self-Induction," by Dr. J. A. Fleming, member; and (2) on "Some Points Connected with Mains for Electric Lighting," by W. H. Preece, F.R.S., past president.

Lightning Conductors.—The Warwick borough surveyor's report mentioned that the lightning conductor at the sewage farm chimney was broken, and Mr. Radcliffe, electrical engineer, estimated to repair the same for £7. Alderman Cooke said it appeared that not only was it entirely out of repair, but there had been no proper earth connection, so that it was far worse than useless.

Tramways Exhibition.—We are officially informed that an exhibition of appliances connected with tramways will be held at the approaching meeting of the Tramway Institute in July next. We should think it will be worth the while of electrical engineers to make strenuous efforts to place before the institute all possible electrical inventions applicable to tramway working, of which many are only awaiting opportunity of further extensive application. The office of the institute is at St. Stephen's House, 2, Coleman-street.

Electric Power in Manchester.—A correspondent writing to the *Manchester Guardian* says: "I wish to urge

Manchester to supply electricity to the surrounding towns for motive power purposes. A central station ought to be established to supply 500,000 h.p. to Bury, Ramsbottom, and Haslingden. There would be a good demand for it. Both large and small works would substitute electric motors for steam engines. I hope a company will be formed to supply it on a large scale, say for a radius of 20 miles. We ought to have had it long since. The whole work could be accomplished in 12 months' time."

Private Scotch Telephones.—Messrs. Cox-Walkers, electrical engineers and manufacturers, of Darlington, have been entrusted with the instructions of his Grace the Duke of Hamilton, through his Edinburgh agents, to erect a line across the Island of Arran from Brodick Castle to the shooting lodge at Dougherie, a distance of about 10 miles, and to complete telephonic communication between these two places, and also with the chamberlain's offices at Strabane, and the postmaster's house at Brodick. A commencement was made with the work this month, and the firm expect to complete it in a few weeks.

Improvements at Rhyl.—People who are accustomed to spend their holidays at this delightful seaside resort will be pleased to learn that the new company who recently purchased the pier, which extends 800 yards into the sea, have arranged with a leading firm of Liverpool contractors to erect a pavilion on the pier, from plans prepared by Messrs. Darbyshire and Smith, of this city. The hall, which is to be finished by July 25, will accommodate about 3,000 persons. The pavilion and pier will be lighted with the electric light. Terms have been settled for the purchase of the grand organ of the Manchester Jubilee Exhibition.

Telephoning Across the Border.—The National Telephone Company, Limited, have arranged to run a direct trunk wire from Glasgow to Dumfries, and thence to Carlisle. The line will be specially constructed to give efficient long-distance speaking, and will be the first telephone line to cross the border. Glasgow and the West of Scotland will then be put into direct communication with the iron districts of Cumberland and Westmoreland, which are already connected with Carlisle, and this will form an important link in the proposed chain of communication between the principal towns and cities of Scotland and England.

Amsterdam.—The concession for the electric lighting of Amsterdam has been given to the Electra Society, a local company. The erection of a central station and laying of the mains for a capacity of 20,000 lamps of 16 c.p. has been given into the hands of the Helios Company, of Cologne, licensees of the Ganz system. The installation will comprise three alternate-current Zipernowski dynamos of 320,000 watts, separately excited, and a dynamo of the same system of 160,000 watts. The first will be driven by two steam engines of 600 h.p. each, and the fourth will be coupled direct to an engine of 300 h.p. The central station will be established about two miles from the centre of the town.

Fire at Fowler and Lancaster's.—A fire occurred on Wednesday at the showroom and central office of Messrs. Fowler, Lancaster, and Co., at Birmingham. The outbreak was caused by a curtain being blown near to the fireplace, and being ignited by sparks, or by a cinder falling upon it. The showroom was completely gutted, and an immense amount of damage has been done to a number of electroliers and brackets, and a large stock of switches and other fittings, to the amount of several hundred pounds, part only of which is covered by insurance. Messrs. Fowler, Lancaster, and Co. inform us that this will in no way interfere with their business, and that they will be able to execute orders with their usual promptitude.

Revocation of Provisional Orders.—In the House of Commons, April 23, in reply to Mr. S. Balfour, Sir M. Hicks-Beach said the Board of Trade have no power to revoke a provisional order unless the undertakers fail to comply with the requirements of the order within the prescribed time. In the only case in which the Board of Trade propose to grant a third order in a district this session they have reason to believe that one of the existing companies will not be in a position to comply with the requirements of their order within the time prescribed thereby. If this should be so, the Board of Trade will, when the proper time arrives, consider any application for the revocation of the order that may be made to them by the county council or the local authority.

Telegraph from India to China.—The through telegraph route is greatly desired from India to China. The Chinese wire has reached Momein, a short distance from the Upper Burmah frontier. It has been urged that a line could be run direct across the hills to Momein, thus giving a through overland route. This part is held, however, by lawless tribes, and attention has been turned to the Lashio route from Mandalay to Kunlon Ferry, on the Salween. According to the Indian papers a railway will in all probability be built within a few years from Mandalay to Lashio, and there would be no great difficulty in running the telegraph line in advance. In the near future it is thought possible we may see the telegraph extending through to meet a short Chinese extension from Momein.

Conversazione at Finsbury.—The Students' *conversazione* will be held on Friday, May 15th, commencing at 7.30 p.m., at the City and Guilds of London Technical College, Leonard-street, Finsbury. Some of the leading engineering, electrical, and chemical firms have consented to lend apparatus and products for exhibition. During the evening Prof. S. P. Thompson, D.Sc., will deliver a lecture entitled "Electricity in Motion." A concert will be given under the management and by the kindness of the musical committee of the Old Students' Association. Dr. Wormald has given the use of the large hall at the Cowper-street Schools, in which there will be an exhibition of *tableaux statuaires*, and later in the evening a dance. Tickets (4s.) can be obtained from Mr. J. T. Eliott, at the Finsbury Technical College.

Electrical Students.—Electricity, says the *Daily Telegraph*, has the merit not only of providing good light and speedy communication, but also profitable employment to an ever-increasing number of individuals. The eleventh annual report of the City and Guilds of London Institute for the Advancement of Technical Education states that the section at the Central Institution and the Technical College in Finsbury which has drawn the greatest number of students is the electrical department. At both colleges these classes are overcrowded, and, what is more important, all those who completed their course at the end of last session have obtained employment. In all its branches the institute last year was eminently successful. At the central school the number of students has increased 50 per cent.; at the other institutions in Finsbury and South London the classes are filled to the utmost limit.

Glasgow.—The Glasgow Sub-Committee on Electric Lighting are of opinion and have resolved to recommend that the Corporation should undertake the laying down of the necessary works and plant for generating and supplying electricity for private and public lighting within the compulsory area scheduled in the Glasgow provisional order, under such professional advice and superintendence as may be deemed requisite or expedient. In the event of the recommendation being approved of by the Town Council, the Electric Lighting Sub-Committee will forthwith invite tenders from competent contractors for the execution of the various works. It is expected that in the course of the next few days the Electric Lighting Committee will issue the reports they have received from Mr. R. E. Crompton, Prof. Jamieson, of the Glasgow and West of Scotland Technical College, and Sir William Thomson, P.R.S.

Hackney.—At the meeting of the Hackney Board of Works last week, an application from the Laing, Wharton, and Down Construction Syndicate was discussed, for permission to provide electric lighting for the main thoroughfares in the district. Messrs. Laing-Wharton said they were willing to enter into an agreement to deposit with the Board, with one month after confirmation by Parliament of the provisional order, £1,000 as a guarantee of their *bona fides* to carry out the work, or transfer the power to do so to some company, before the expiration of two years and four months, after which period the guarantee sum was to be repaid without interest. In the discussion which followed a good deal of opposition was expressed to the scheme to the granting of a monopoly to the syndicate. One member maintained that the electric light would cost double the present price of gas. The project was also objected to on the ground of danger to life and property. The Board eventually decided, by a majority of 22, not to accede to the application.

Bath.—The fortnightly meeting of the Bath Surveying Committee held on Monday had before them copies of the report of Prof. Forbes, called in to examine on behalf of the authority the installation of the electric light, together with correspondence which had taken place upon it and a report from the Electric Light Sub-Committee upon the whole matter. Mr. Sturges suggested that the committee should approve of the report and send it up to the Urban Sanitary Authority for full consideration at their next meeting. The chairman expressed a strong opinion that the committee should first of all have time to fully consider the report; they would not be doing the duty entrusted to them if they approved of a report without reading it. Mr. Sturges saw the force of the observations. The clerk said the next meeting of the Urban Sanitary Authority would be on the 28th inst., but it would be necessary to have another meeting about a fortnight or three weeks after. It was decided to postpone the consideration of the subject till the next meeting.

London County Council Tenders.—The London County Council, on January 13, gave the Offices Committee authority to obtain tenders for the necessary fittings for providing the electric light for the large room under the Council-chamber, and for one of the rooms on the ground floor occupied by some of the clerks in the clerk's department. After they had obtained this authority, it appeared that it would be advantageous to extend at the same time the electric light to the chief engineer's room and others. They accordingly gave instructions for the fittings for these rooms to be included in the specification. Tenders were invited from seven firms, and the following were received—viz.: Messrs. Thompson and Ritchie, £172. 6s.; Messrs. Crompton and Co., £210. 10s.; Mr. H. South, £240; Messrs. M. J. Scott and Co., £245; and Messrs. Strode and Co., £248. They recommended that, subject to an estimate being submitted to the Council by the Finance Committee as required by the statute, the tender of Messrs. Thompson and Ritchie be accepted, and that the solicitor be instructed to prepare a contract with them accordingly.

Electrical Training for Nurses.—A medical electrical institution, under the title of the Grafton College, for the training of nurses and others in medical electricity and massage, has been recently started at 35, Fitzroy-square, W., by Mr. H. Newman Lawrence, M.I.E.E., and his able colleague Dr. Arthur Harries. It forms a fresh evidence of the energy of these gentlemen in their efforts to place in a satisfactory and scientific position medical electricity and its cognate subjects. We have been favoured with copies of the syllabus of lectures for the term, and also with the questions set at the examinations which concluded the first term's work. From these it is evident that a very useful training is to be obtained at the college. Anatomy, pure electrical science, and electricity as applied to medical purposes are therein dealt with. The value of the certificate given to the successful student is clearly enhanced by the fact that independent examiners, in the persons of W. E. Sumpner, D.Sc. (Lond.), and J. Russell, M.D., M.R.C.S., have been called in to examine, the former on electricity and the latter on anatomy and physiology. We note that some free studentships are offered to trained nurses, and trust that Grafton College may receive the support it merits.

Screws and Screwmaking.—The appearance of a book on screws is certainly an evidence of the extreme of specialisation we have come to in this present scientific age, and that a work of over 200 pages can be given on this single subject shows that it must have been treated exhaustively. "Screws and Screwmaking, with a chapter on Milling Machines," is the title of the work before us, edited for, and published by, the Britannia Company, of Colchester, (3s.), and it seems to bear out its promise of being a complete treatise. Much of the information given is accessible only in reports or societies' *Transactions*. The classic paper by Whitworth is given in full, and also the considerations which led to the adoption of the Sellers system in America, and the system tabulated for the Geneva Society of Arts by Prof. Thury. Tables are given of nearly 1,000 thread rates from one turn in 16in. to 1,000 turns per inch. Possessors of this volume have before them practically the whole theory of the art of screw cutting, and rules and tables for every purpose. The book is abundantly illustrated with cuts of specimen threads, taps, screw-plates, screwing machines, which, though not unnaturally in many cases of the Britannia Company's manufacture, aid the understanding of the subject, and should prove extremely useful.

Weems Express.—That the plan of running an express electric train at speeds up to 200 miles an hour is in any way possible, is very much doubted by many people, and especially the continental papers, who represent views not so hopeful and daring as those of American engineers. *Electricité* alludes to the plan as "fantastic." But the scheme, however daring it is, seems to have got beyond the fantastic stage. Mr. Wetzler, editor of the New York *Electrical Engineer*, when he was in England, informed us that, watch in hand, he had seen the experimental car make its round of two miles within one minute. It is by no means the least interesting part of the scheme that the inventor, whose mind may naturally be considered sanguine, has induced Mr. O. T. Crosby, a well-known and capable engineer hitherto in the Sprague Company (one of the largest electric railway companies in America) to cast in his lot for the execution of this express railway: and the New York *Electrical World* for March 14 and 21 contains Mr. Crosby's paper giving full particulars and drawings of the proposed passenger express. In a country where time is so valuable as the United States, and where it now takes seven days to cross from New York to San Francisco, a scheme of rapid travelling such as this, if taken up by practical men, may with some probability be expected before very long to lead to results which will astonish the sceptics. At any rate, we certainly see a

Manchester to supply electricity to the surrounding towns for motive power purposes. A central station ought to be established to supply 500,000 h.p. to Bury, Ramsbottom, and Haslingden. There would be a good demand for it. Both large and small works would substitute electric motors for steam engines. I hope a company will be formed to supply it on a large scale, say for a radius of 20 miles. We ought to have had it long since. The whole work could be accomplished in 12 months' time."

Private Scotch Telephones.—Messrs. Cox-Walkers, electrical engineers and manufacturers, of Darlington, have been entrusted with the instructions of his Grace the Duke of Hamilton, through his Edinburgh agents, to erect a line across the Island of Arran from Brodick Castle to the shooting lodge at Dougherie, a distance of about 10 miles, and to complete telephonic communication between these two places, and also with the chamberlain's offices at Strabane, and the postmaster's house at Brodick. A commencement was made with the work this month, and the firm expect to complete it in a few weeks.

Improvements at Rhyl.—People who are accustomed to spend their holidays at this delightful seaside resort will be pleased to learn that the new company who recently purchased the pier, which extends 800 yards into the sea, have arranged with a leading firm of Liverpool contractors to erect a pavilion on the pier, from plans prepared by Messrs. Darbyshire and Smith, of this city. The hall, which is to be finished by July 25, will accommodate about 3,000 persons. The pavilion and pier will be lighted with the electric light. Terms have been settled for the purchase of the grand organ of the Manchester Jubilee Exhibition.

Telephoning Across the Border.—The National Telephone Company, Limited, have arranged to run a direct trunk wire from Glasgow to Dumfries, and thence to Carlisle. The line will be specially constructed to give efficient long-distance speaking, and will be the first telephone line to cross the border. Glasgow and the West of Scotland will then be put into direct communication with the iron districts of Cumberland and Westmoreland, which are already connected with Carlisle, and this will form an important link in the proposed chain of communication between the principal towns and cities of Scotland and England.

Amsterdam.—The concession for the electric lighting of Amsterdam has been given to the Electra Society, a local company. The erection of a central station and laying of the mains for a capacity of 20,000 lamps of 16 c.p. has been given into the hands of the Helios Company, of Cologne, licensees of the Ganz system. The installation will comprise three alternate-current Zipernowski dynamos of 320,000 watts, separately excited, and a dynamo of the same system of 160,000 watts. The first will be driven by two steam engines of 600 h.p. each, and the fourth will be coupled direct to an engine of 300 h.p. The central station will be established about two miles from the centre of the town.

Fire at Fowler and Lancaster's.—A fire occurred on Wednesday at the showroom and central office of Messrs. Fowler, Lancaster, and Co., at Birmingham. The outbreak was caused by a curtain being blown near to the fireplace, and being ignited by sparks, or by a cinder falling upon it. The showroom was completely gutted, and an immense amount of damage has been done to a number of electroliers and brackets, and a large stock of switches and other fittings, to the amount of several hundred pounds, part only of which is covered by insurance. Messrs. Fowler, Lancaster, and Co. inform us that this will in no way interfere with their business, and that they will be able to execute orders with their usual promptitude.

Revocation of Provisional Orders.—In the House of Commons, April 23, in reply to Mr. S. Balfour, Sir M. Hicks-Beach said the Board of Trade have no power to revoke a provisional order unless the undertakers fail to comply with the requirements of the order within the prescribed time. In the only case in which the Board of Trade propose to grant a third order in a district this session they have reason to believe that one of the existing companies will not be in a position to comply with the requirements of their order within the time prescribed thereby. If this should be so, the Board of Trade will, when the proper time arrives, consider any application for the revocation of the order that may be made to them by the county council or the local authority.

Telegraph from India to China.—The through telegraph route is greatly desired from India to China. The Chinese wire has reached Momein, a short distance from the Upper Burmah frontier. It has been urged that a line could be run direct across the hills to Momein, thus giving a through overland route. This part is held, however, by lawless tribes, and attention has been turned to the Lashio route from Mandalay to Kunlon Ferry, on the Salween. According to the Indian papers a railway will in all probability be built within a few years from Mandalay to Lashio, and there would be no great difficulty in running the telegraph line in advance. In the near future it is thought possible we may see the telegraph extending through to meet a short Chinese extension from Momein.

Conversazione at Finsbury.—The Students' *conversazione* will be held on Friday, May 15th, commencing at 7.30 p.m., at the City and Guilds of London Technical College, Leonard-street, Finsbury. Some of the leading engineering, electrical, and chemical firms have consented to lend apparatus and products for exhibition. During the evening Prof. S. P. Thompson, D.Sc., will deliver a lecture entitled "Electricity in Motion." A concert will be given under the management and by the kindness of the musical committee of the Old Students' Association. Dr. Wormald has given the use of the large hall at the Cowper-street Schools, in which there will be an exhibition of *tableaux statuaires*, and later in the evening a dance. Tickets (4s.) can be obtained from Mr. J. T. Eliott, at the Finsbury Technical College.

Electrical Students.—Electricity, says the *Daily Telegraph*, has the merit not only of providing good light and speedy communication, but also profitable employment to an ever-increasing number of individuals. The eleventh annual report of the City and Guilds of London Institute for the Advancement of Technical Education states that the section at the Central Institution and the Technical College in Finsbury which has drawn the greatest number of students is the electrical department. At both colleges these classes are overcrowded, and, what is more important, all those who completed their course at the end of last session have obtained employment. In all its branches the institute last year was eminently successful. At the central school the number of students has increased 50 per cent.; at the other institutions in Finsbury and South London the classes are filled to the utmost limit.

Glasgow.—The Glasgow Sub-Committee on Electric Lighting are of opinion and have resolved to recommend that the Corporation should undertake the laying down of the necessary works and plant for generating and supplying electricity for private and public lighting within the compulsory area scheduled in the Glasgow provisional order, under such professional advice and superintendence as may be deemed requisite or expedient. In the event of the recommendation being approved of by the Town Council, the Electric Lighting Sub-Committee will forth-possibility of higher railway speeds, and we can, at least, hope for the practice.

O.S.A. Revels.—At a smoking concert of the Old Students' Association on Friday night, some 100 or so of the past and present students of the Finsbury and Central Technical Colleges met together at the tavern in Basinghall-street for congenial intercourse. One member was much applauded by indulging in a song explanatory of how O'Hara was pitched into by his friends, mopped around the floor, thrown under the table, and chucked downstairs. Another gentleman created great amusement by indulging in the most awful grimaces it has ever been, one would think, the good fortune of the students to witness, with the aid of a painted face, a tangled wig, and a particularly red nose. Another gentleman let off his vivacity in a chorus of the most ear-piercing shrieks and whistles, energetically casting back his head and howling like a dog. Music hall songs were given with great gusto, and the fight between an Irish giant and his rival and the forcible carrying off of the bride was also described. The concert was also enlivened by one or two very good songs, and by some capital violin playing. The students revelled in cigars, whisky, and beer, and went home smelling strongly of tobacco. These meetings are evidently felt exhilarating and pleasant, and seem calculated to afford an admirable relaxation and change for young students after hard work and study.

Edinburgh and Leith.—The Corporation of Edinburgh are at present in Parliament seeking a provisional order which will enable them to provide electric lighting; one of the provisions of which is that they may transfer their responsibility to the Gas Commissioners or anyone else. The Corporation of Leith objected to this clause, on the ground that they were joint-owners of the gas undertaking, and that it would be unjust to enable the Corporation of Edinburgh to transfer an electric lighting order for the lighting of the city of Edinburgh only, and to use the assets and revenues of the Gas Commissioners for such a purpose without the consent of the Corporation of Leith. The Board of Trade took the same view as the Leith Corporation; and to satisfy the Board, the clause which was objected to has been amended so as to provide that the Corporation shall not effect a transfer to the Gas Commissioners without the consent of the Corporation of Leith. As amended, the clause will enable the Corporation of Edinburgh if they see fit, with the consent of the Corporation of Leith, to transfer their powers and obligations to the Gas Commissioners, rather than allow a private company to be established within the city to compete against the public undertaking for the lighting of the city with gas. But of what use will any such transfer be? asks the *Journal of Gas Lighting*. Before it will be consented to by the Leith Corporation, it cannot be doubted they will require a guarantee that any loss of revenue to the Gas Commissioners will be made good out of the Edinburgh rates.

Barnet.—The Lighting Committee of the Barnet Local Board at the last meeting reported that applications from four firms were received asking for particulars of the electric lighting of the town. The committee have, with the help of a map, carefully considered the lighting of the district, and, subject to further consideration, recommend that each contractor be informed that about 33 incandescent lamps of 32 c.p., six of 16 c.p., 10 arc lamps of 500 c.p., and three arc lamps of 1,000 c.p. will be required. Also that as the district may be extended to more than double its present dimensions, provision will have to be made for lighting such extended district. Also that the ard will themselves obtain a license or provisional order *lighting the town*, and would like to know at what price per lamp the contractors would provide and lay all plant for the efficient lighting of the district. The clerk handed round to members a list of the proposed points where lamps should be placed. The chairman said it was to be understood this was only a suggested list. The clerk said he had sent particulars to the four firms of contractors applying in response to the advertisement, but had only received one in reply, from the Electric Installation and Maintenance Company, Limited, offering a scheme and estimate for construction of the necessary plant and working of the station. The clerk said he had asked the company their terms for seven, 14, and 21 years. It was resolved that the letter be referred to the Lighting Committee to deal with, and that if any further communication was received, the committee should meet before next Board. The clerk stated that the present contractor had not tendered.

Utilisation of Water Power in Ireland.—The following additional particulars of the installation for transmission of power at the mills of C. Arthur Webb, Esq., of Quartertown, near Mallow, are furnished us by Mr. G. B. Garvey, B.A., M.E., who carried out the installation for the Electrical Engineering Corporation, of 68, Victoria-street. Mr. Webb had two mills worked by the same stream, about 600 yards apart. The lower mill was burnt down some time since, but the waterwheel and gearing escaped. The upper mill is worked by a waterwheel and steam engine conjointly. The idea occurred to Mr. Webb of conveying the power from the idle wheel back to the first mill on the stream by electricity, and then stopping the steam engine. The order, after due enquiry, was placed with the above firm. The dynamo used at the lower mill is a Statter-Brunton compound-wound dynamo, fitted with their patent automatic constant-current gear, and runs at a speed of 900 revolutions per minute. The output of this machine when fully loaded is 45,000 watts, or 75 amperes, at a maximum pressure of 600 volts. The motor is of the same design as the dynamo, and is also fitted with a Statter-Brunton patent constant-current gear, controlled by a sensitive centrifugal governor for working with the above generator. The speed of this machine is 700 revolutions per minute. These machines have been carefully designed for this work, and their special adaptability for such a purpose will be readily understood on account of automatically regulating, as they vary their load to the requirements of the mill, thus needing no attendant to shift the brushes. The line connecting the two mills is of insulated cable, run on poles overhead, and is fastened to Johnson and Phillips's patent fluid insulators. The switchboard is mounted on slate, and is fitted with the necessary cut-outs, switches, and measuring instruments. A second dynamo by the same makers is also driven by the same waterwheel, and is used for lighting the mills and houses belonging to Mr. Webb.

Painless (!) Extraction.—Mr. H. Fielden Briggs, of Torquay, doctor of dental surgery, L.D.S., diploma in electro-therapeutics, etc., is certainly a martyr to the cause of science. Writing to the *Western Morning News*, he states how, seeing a notice of a new electrical method of extraction of teeth in an absolutely painless method, he went up to London to test its merits personally. Not having a decayed tooth, he resolved to sacrifice a sound one, believing practice to be better than theory. "I was referred," he says, "to the surgery of a qualified dentist, when the performance began. The instrument, in order that the armature should vibrate 452 times to the second, was tuned up to A, and emitted this note during the operation. I was seated in the chair holding in both hands the handles from a battery. The current was sent through me until I could bear it no longer, when it was stopped for the present.

The forceps, also connected with the battery, were adjusted to the tooth. The current was then turned on through the tooth and at the same time through the handles, which I still held, during which time the tooth was extracted and the current then stopped. During this process the sensation to me was like being the central figure at a miniature execution by electricity, for I not only felt the pain of the tooth, but also pain about the head and face and up the arms. This was combined with the helpless feeling of not being able to let go the handles while the current was going on. After it was over, on my saying it had hurt a good deal, the dentist replied, 'With due deference to you I must say it didn't.' I then intimated that I was more likely to be the better judge of that. I have had teeth out painlessly by the aid of the recognised anæsthetics, and one without any pain obviater, which of course was painful, but not nearly so unendurable as the one removed by the assistance of the so-called electrical pain preventer. The latest instrument is no better than its predecessors. If anyone doubts this, let him go and try it for himself." It is hardly possible to conceive how it should come into use at all if it acts upon all patients as it did upon Mr. Fielden Briggs.

Agricultural Hall.—The Ironmongers' and Electricians' Exhibition at the Agricultural Hall is rather a poor affair this time. There is a considerable number of gas engines of various makes, but for the rest, and especially in electrical fields, there is an almost entire dearth of interesting exhibits. Of those that are there Messrs. Gritten and Parmley have the most novel exhibit in the shape of specimens of their fireproof plaster moulding for electric light wires. Another which is certainly worthy of careful attention by electrical engineers is the oil-gas apparatus of Messrs. Edwin Mansfield and Sons, 140, Great Clowes-street, Manchester. In this a cast-iron retort is heated to redness, and oil of any kind or any greasy substance is allowed to drip into the inside. It immediately dissociates into its constituent parts, and never recombines even when cooled. The gas thus obtained is put through a water vessel and into a gasholder and can be used to drive an ordinary gasholder. One of these is used at Jerusalem for driving a large Otto engine, and the Japanese and Indian Government have also ordered. The cost of the gas is given at 2s. 6d. per 1,000 cubic feet. It should be exceedingly useful for country mansions.—Jas. Joicey, Esq., M.P., of Longhurst, Northumberland, has a dynamo driven by this apparatus. Some good manhole covers are shown in the exhibition, a tight-fitting circular one by Durrans, and a self-jointing manhole cover, with very good points in its favour, by Mr. John Jones, of 40, Sidney-street, Chelsea, in which the vapour rises to an apex in the interior cover, trickles down, and forms its own water-seal. Messrs. Hulett and Co., of Holborn, had specimens of the E.S. dry battery. A new importation, the "Freedman battery," for bells, was shown by Messrs. Charles Atkins and Nisbet, of 1, Water-lane, sole agents. It is a dry cell requiring no attention. Of gas engines, as we have said, there are quite a number—Crossley's Otto, the Stockport, Campbell of Halifax, the Griffin, Woodhead of Leeds, Clayton of Bradford, the Trent gas engine (in which explosion takes place in a separate chamber and can be regulated to steadily run at very varying speeds), and the Colne (a new type of gas engine made at Twickenham). The Blackman air propeller and Wings disc fan are shown. Messrs. F. Jones and Co. have many adaptations of their silicate cotton to fireproof and heatproof purposes. A small heat engine is shown by Messrs. F. W. Potter and Co., Great Eastern-street, E.C., driving small machinery.

Electric Cranes for Southampton.—The sub-committee of the Special and General Works Committee of the Southampton Harbour Board reported enquiring of the Southampton Electric Company whether they could supply power to work two cranes on the Town Quay, and the receipt of a reply from the company's engineer, stating that the company would charge a rate of 6d. per unit, equal to a fraction over 4d. per horse-power, and that price would apply for light as well as power. The company would lay mains to the commencement of quay, and the cost of laying down cable and purchase of two cranes, with a radius of 25ft. to 30ft., fitted on gantries, and lifting two tons 200ft. per minute, would be about £2,000. The sub-committee resolved to recommend the adoption of electric cranes, Mr. Scovell being neuter. At a meeting of the General Committee a letter was received from Mr. Aldridge, engineer to the electric company, stating that he had obtained an absolute tender from a firm of crane makers for cranes, to lift two tons 200ft. per minute, fixed complete, at £937 each. This would be independent of cable required on Board's own property.—Sheriff Bone, in proposing the adoption of the report, stated that it was 15 months since the committee brought up a report to the Board, recommending that provision of increased facilities for the shipment and discharge of cargo on the Town Quay should be taken into consideration. The subject had required serious consideration, and seeing that they had other important things to do in the past 12 months there had not been much delay. The committee called in two experts as to the providing the cranes and the motive power. It was thought that the initial cost of providing the necessary plant for hydraulic power and increasing the strength of the quay would be so great that the idea had to be abandoned. Next, they considered compressed air as the motive power, feeling it could be supplied from the destructor works, but on applying to the Corporation they refused, stating that they had not more power than they wanted for their own work. As to providing the necessary plant for manufacturing or generating the compressed air, the cost would be so great that, like the other, they had to abandon it. Then with regard to steam or electric cranes, after carefully going into the matter they found that the cost of providing two cranes, lifting two tons 200ft. per minute, with a radius of 25ft. to 30ft., would be about the same, whether by steam or electricity; but in regard to the working they found that the cost of electricity would be less than to use steam, in addition to it being much cleaner and more easy for the men to work. They would be able to switch it on at once, and there would be no delay in getting up steam. The committee approached the Southampton Electric Light Company, asking, if the Board adopted the electric system, whether the company would supply the motive power? They had answered that they would supply it at a sum which would bring it to a less cost than steam, and, further than that, would give a guarantee for successful working for seven years, if the Board would guarantee to be supplied with the power for that length of time. That was only fair, as they could not expect the company to increase their plant, and lay down a cable to the quay, unless they would take it. The cost of providing the cranes, etc., would be about £2,000, but, in addition, there would have to be a little strengthening of the quay, and a line of railway to be laid down for the cranes to run on. Eleven out of 13 members of the committee were present, and they were unanimous in recommending the adoption of the report. If the Board gave greater facilities for trade, it was to be hoped that their example would be followed by the large companies in the port. After further discussion, the report was adopted.

TRANSMISSION OF POWER BY ROTARY-PHASE ALTERNATE CURRENTS.*

BY M. VON DOLIVO-DOBROWOLSKY.

(Continued from page 409.)

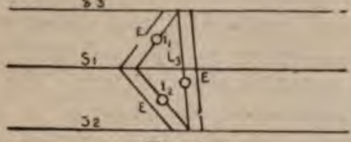

FIG. 1.

In order to determine the conductor sections for an interlinked rotary current applied in the way indicated for long-distance transmission, it is first of all necessary to obtain a clear conception of the amount of energy transmitted by the three conductors combined. In other words, we have first to answer the question, How large is the total energy, if current intensity and pressure have been measured? This question needs to be solved at first only by way of comparison with the ordinary alternate current, and we will thereby assume all the receiving apparatus to be without self-induction—*i.e.*, that they cause no displacement of the current against the pressure. Does it, moreover, occur that the modifications produced in the rotary current are the same as in the alternate current? Further, we will select the case that the three branches are equally loaded, as, in order to calculate the conductor sections only, the full normal load is to be taken into consideration. Fig. 1 represents three conductors carrying a rotary current of the intensity I at the pressure e. I therefore denotes either the maximum, or the effective, or the average current intensity, but not the variable intensity at any moment. The load is represented by the three equal branch currents, i_1, i_2, i_3. The flow of current, as already referred to, is such that each current has its return way in the two other conductors, and that the current maxima in the conductors follow one another in a distance of 120deg. Then I_1 is split in i_1 and i_2, I_2 in i_2 and i_3, etc.; i_1 is thereby displaced against i_2 by 60deg. Therefore

$$I = 1{\cdot}732\, i.$$

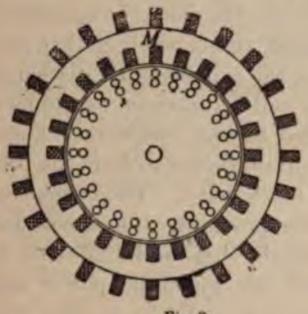

Fig. 2

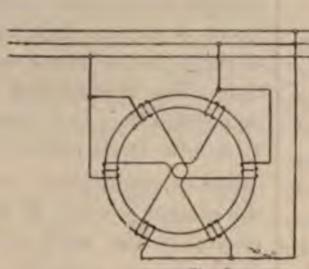

Fig. 3

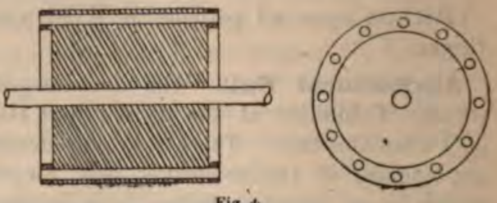

Fig. 4

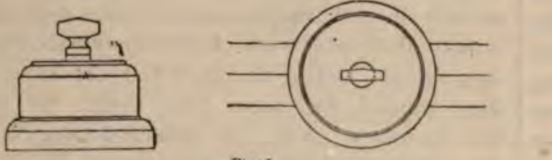

Fig. 5

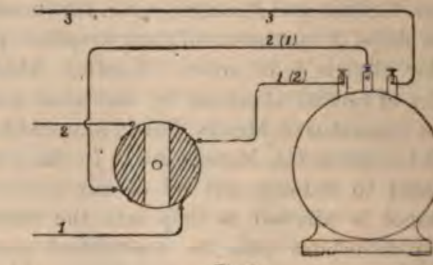

Fig. 6

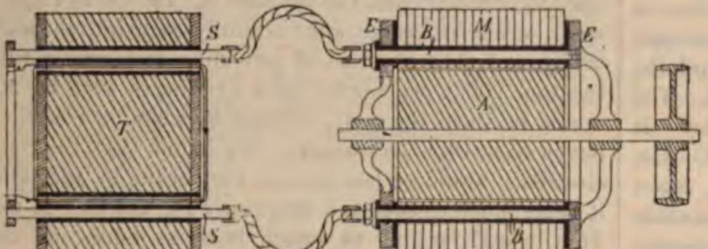

Fig. 7

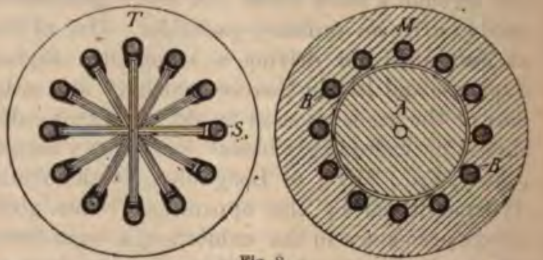

Fig. 8

Hence, on the other hand, it follows that the maxima of the currents I do not coincide with those of the currents i, but that the maximum of I occurs in the middle, between the maxima of i_2 and i_3, the resultant current, I, being thus at a distance of 30deg. from the single currents.

According to the assumption above made, that the receiving apparatus is without self-induction, there is no displacement between the pressure and the current generated by it, so i appears at the same time as e. On the contrary, between e and I there is a phase-distance of 30deg., as I and i are displaced by 30deg. against each other. In other words, in an interlinked three-phase current there is a phase-distance of 30deg. between the current of the one main conductor and the pressure between two neighbouring conductors. The whole energy is $= 3\, i\, e$—that is, = 3 times the energy of one single branch. Now, introducing for i the value

$$\frac{I}{2 \sin 60\text{deg.}},$$

we get for the total energy:

$$3\, i\, e = 3\, e\, \frac{I}{2 \sin 60\text{deg.}} = 1{\cdot}732\, I\, e,$$

That is to say, if the interlinked rotary current has in all the three conductors an effective intensity = I, at the pressure e, the power transmitted is = 1·732 I e.

Hence, if we want to transmit the same power at the same pressure, e, by a continuous or alternate current, the effective current strength must be = 1·732 I. Now, as for the same length of conductors and the same loss of pressure, we have to make the cross-sections proportional to the current strength, it follows that if the three conductors of the rotary current must have each a cross-section = g, corresponding to the current I, in employing continuous or alternate currents, we shall require two conductors, each having a cross-section = 1·732 g. The rotary-current conductors used for long-distance transmission may therefore be first calculated, so to speak, as if for a two-conductor current, and then the sum of the two-conductor sections is to be divided upon three wires, whereby the cross-section so obtained can be still diminished by about 13 to 14 per cent. It results, from the above consideration upon the relation of the main line current to the receiving current, that for each ampere in the main conductors, 0·866 A can be taken off each receiving current circuit. Or a rotary current of 1 A may be split in three alternate currents of 0·866 A at the same pressure, and a rotary current of 1 A at 100 V represents a power of 173·2 watts. We explicitly repeat, then, that the above relations only hold good when (1) the three branches are equally loaded, (2) the load is free of self-induction, and (3) the currents are measured by means of separate ampere-meters and voltmeters, and not by wattmeters. In the latter case the product I × *e* will be less, since, as above stated, between I and *e* there exists a constant phase-distance of 30deg.

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* Translated from the *Electrotechnische Zeitschrift.*

All these discussions have, however, only a limited value for practical work, as, for one thing, the first of the three conditions will never, or very seldom, be practically fulfilled. As above pointed out, the currents employed at the central station to generate the rotary current, being not interlinked—*i.e.*, independent one from another—the control of loadings and the regulation of currents are extremely simple. As to the measurement of consumption at places of utilisation, this is again also very simple, as the interlinking is mostly unlinked at these places. The lamps receive only two conductors, the consumption being measured by means of simple electricity meters; larger motors receive separate circuits, the consumption being registered by means of suitable wattmeters. Finally, at small motors fed by an interlinked rotary current, the measurement of one of the currents suffices without a correction relative to an eventual inequality of the single currents.

The electromotors themselves are built, as already mentioned, on the Ferraris-Tesla principle—*i.e.*, the different multiple-phase currents generate a rotating magnetic field of almost constant intensity, and this "rotary field" constrains a closed-coil or correspondingly arranged armature to follow its rotation. According to the design, to the special conditions and to the size, the motors are given a different arrangement. Very small motors (up to ¼ h.p.) are built according to the scheme shown in Fig. 2. M is the field magnet ring, consisting of thin iron discs, and having inward projections, like Pacinotti teeth. The winding is on the Gramme system, and fills up the intervals between the teeth. Fig. 3 gives a sketch of winding as applied to interlinked rotary current. The armature consists of a massive iron cylinder with numerous perforations parallel to the axis; copper wires pass through these perforations and are metallically connected together by means of two copper end-plates or rings. Fig. 4 shows more accurately the arrangement of this armature.

It is not necessary to supply this armature with current, and such a motor can be scarcely excelled as regards simplicity and safety of working. This simplicity is particularly valuable for these small motors, designed for the constant use of unskilled persons.

The starting is effected (if reversal of direction of rotation is not necessary) simply by turning on the current, for which purpose the Allgemeine Company manufactures a very simple and compact switch, by which all the three circuits are at once switched on or off, Fig. 5. If the motors require to be reversed in their direction of rotation, a simple commutator is used, the operation of which is diagrammatically shown in Fig. 6. The conductors 1 and 2 are, by the movement of the switch, interchanged relatively to the motor, so that the succession, 1 2 3, 1 2 3, 1, etc., is transformed to 3 2 1, 3 2 1, 3, etc. The latter being the opposite of the first, the direction of motor rotation is reversed. If larger motors receive more than three phases, the commutator is, of course, also correspondingly formed.

Another type of rotary-current motors is shown by Figs. 7 and 8. The armature, A, is of the same kind as that represented in Fig. 4, and the field magnet is simplified, inasmuch as here, also, no winding is used. The motor is mostly arranged for far more than three currents; so the motor sketched in Fig. 7 is intended to work with six single currents at a phase-distance of 30deg., in accordance with which six conductors are required. The field magnet is composed of thin iron discs, and held together by means of a frame consisting of end-plates, E, and bolts, B. The bolts are of copper, and are screwed and soldered into one of the bronze end-plates and insulated from the other end-plate by vulcanised fibre or indiarubber. These latter extremities of the bolts serve at the same time as current terminals. Conveniently near the motor, a transformer, T, is set up, fed by three interlinked high-pressure currents, and generating in its secondary windings (rods S) the double number of successive current-phases of a very low voltage. The rods are connected to the corresponding bolts, B, by means of flexible copper cords. In this motor the highest degree of safety is attained, no windings of wires being exposed to a tractive force or to any mechanical strain dependent upon the running of the motor. Its economy and efficiency are not decreased by transformation, inasmuch as, in general, small motors designed for direct use of high pressures cannot be made safe and economical. On the other hand, a considerable economy of space is attained by employing rods instead of windings. The whole motor becomes essentially smaller, and its losses due to copper and iron (hysteresis) become considerably less. This type of rotary-current motors, by reason of its simple construction, the smallness of the attendance required, its freedom from danger, safety of working, and direct applicability to the higher electrical pressures, stands in entire and satisfactory opposition to continuous-current motors.

(To be continued.)

MAGNETIC STANDARDS.

BY JOHN T. SPRAGUE.

Is it quite a fact that electricians will have to go to America to find out "what kind of iron" they have? Surely it has been the practice for a long while to test the quality of various irons, so as to learn before using it what was its "magnetic capacity." The differential magnetometer of Eickemeyer, described p. 370, may be a most useful and practical instrument, but the same work has been done this long while in various manners.

The use of units of intensity, and the idea of maximum intensity of various qualities of iron, is explained in Everett's work on measurements, dating 1875. I have not Kapp's work by me, but, if I am not greatly mistaken, he shows clearly the importance of knowing the capacity of various irons, and gives practical ways of determining and expressing it.

I thought all this was so well understood that I have never said anything about the work I have done, years ago, in this direction, when I was trying ideas of the same order as those so admirably worked out by Prof. Hughes in his Magnetic Researches and Balance. I had a number of pieces of iron of all sorts, and of steel turned down to the same exact size, to serve as cores for a magnetising coil placed at some distance from a small magnetic needle, with a similar coil in the same circuit at an equal distance on the other side of the needle. Of course this is simply the process for measuring magnetic "moment," and by passing a fixed current through, it gives the relative capacities of the different irons, of which we can take any quality we please for the standard; or, if we like, we can use the "air core" of the coil, uncompensated by the opposing coil, for the unit.

But this does not give all the required information. Substituting for the magnet a sensitive ballistic galvanometer adapted to the currents to be dealt with, and for the plain magnetising coil one with a secondary circuit connected to the galvanometer, I measured the induced currents, at make and break, of each sample serving as the core. Again, any particular iron, or the air core reaction, serves for the unit of comparison.

If preferred, a differential galvanometer can be used, or a bridge, with two exciting coils worked by the same current, but opposed to each other in connecting up, one containing the standard, and the other the sample under test.

Of course it is an excellent practical plan to have the test pieces of cast iron formed by projections on the patterns to obtain equality of the mass and sample; but that does not secure the desired result altogether, as anyone will find who casts a thin projection on a heavy rod, and has the latter turned down to the same size. The two parts cast together will give different results.

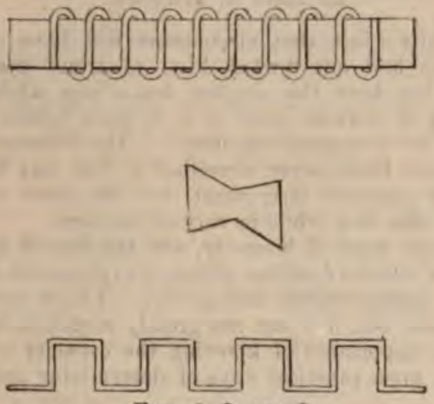
For practical purposes, of course a series of determinations with different currents, and even with different periods of current, is needed to select iron suited for different applications. Eickemeyer's apparatus is no doubt valuable for large concerns, as it is the outcome of experiment to suit varied requirements; but the simple apparatus I have described will give pretty well all the information practically required.

A NEW ACCUMULATOR PLATE.*

BY C. W. PIKE, INSTRUCTOR IN ELECTRICAL ENGINEERING, UNIVERSITY OF PENNSYLVANIA.

While in Lowell, Mass., last year, a temporary craze upon the subject of storage batteries took almost complete possession of the town. The result of this was the production of several so-called new storage batteries. In reality, there was no attempt to produce a new type of accumulator, either by making use of new solutions or new metals. The sole novelty was in the form of the plates.

The inventors had but one object in view—namely, to construct a plate of such form that the active material would not be dislodged from the cavities in which it was held, even by a severe shock or jar. Weight troubled them little, high discharge rate and large capacity less, and efficiency not at all. In spite of this, the results obtained by two of the inventors, Messrs. Bradbury and Stone, were not bad.



FIGS. 1, 2, AND 3.

Two forms of plate were devised by these gentlemen, of which the first is very curious in its construction. Each plate consists of a number of elements, and each element is made by bending two strips of lead into what most of the children, especially among the Germans, call a Jacob's ladder, Fig. 1.

This is then warmed and pulled in the direction of its length, taking care not to allow it to become twisted. When thus pulled out it has a number of interstices, into which active material can be placed. By placing several of these elements side by side, and melting contiguous points together, a complete plate is formed, which is further strengthened by winding a lead strap around its perimeter, and melting points of the plate to it. On looking at the completed plate, it will be seen that every interstice on one side of the plate is connected to another on the opposite side of the plate, so that the active material, when put on, will consist of plugs of the shape seen in Fig. 2, so that the plug, as a whole, could not by any ordinary means be dislodged.

This form of plate has the advantage of large surface of active material and a fairly large ratio of weight of active material to weight of supporting plate, but the cost of making such a plate would more than overcome any advantages which it might have over ordinary forms of grid.

Realising this, the inventors devised another form, made by bending lead strips over sticks of wood, square in section, into the shape shown by Fig. 3. The first strip started from the top of the wooden stick, while the second strip started from the bottom of the stick; the third started from the top and the fourth from the bottom, and so on. The plate, when completed, looked on either side like a checker-board, lead forming the black squares and the uncovered portions of the wooden strips the white squares. The strips were then withdrawn and the plate strengthened, as in their first plate. This form of plate, though cheaper in construction than the former, was yet costly; so that they devised a mould, by which they were enabled to cast the plate entire, Fig. 4.

These plates before being filled are treated for a little while like a Planté, with a view to making the active material adhere strongly to the plate. The positives are then filled with red lead, and the negatives with litharge. The active material can be put into the plates in three ways: (1) As a paste. (2) As a powder, forced in under pressure. (3) By pressing the oxides into sticks and driving these in.

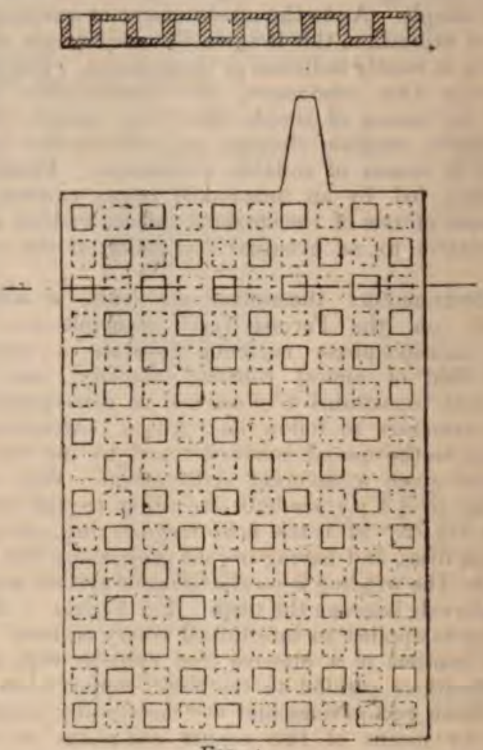


FIG. 4.

I have suggested another method—namely, casting the plates around these sticks, virtually using them for a part of the mould.

Each plate has a lug cast on its top, and the plates of similar polarity are connected together by a lead strip cast to these lugs, Fig. 5. On the top of this connecting strip is also a lug, of the shape of a truncated cone, which serves to connect one cell to the next by means of a connector, of the shape shown in Fig. 6. This device is extremely simple and convenient, but, like all connectors, requires watchfulness in order to secure good contact.

On looking at this plate it seemed to me that it would accomplish very thoroughly the object for which it was designed—namely, to hold the active material in. Also that it would not buckle even when a very strong current was sent through it. Both of these opinions I have since found to be verified; the cells enduring an immense amount of jarring and short-circuiting without perceptible injury.

My impressions in regard to other points were less favourable. Of the total weight of a filled plate, but 38 per cent. is active material; and of the total surface of the plate exposed to the electrolyte, but 30 per cent. is active material. Further, the plates are so thick that the inner portion of the active material will not be acted upon when the cell is rapidly discharged, since the outer portion which has changed from lead peroxide to lead sulphate prevents fresh sulphuric acid from permeating as far as the peroxide inside with sufficient rapidity to keep up the E.M.F. of the cell.

These considerations led me to believe that the internal resistance would be rather high, and its storage capacity and efficiency low, unless a low rate of charge and discharge was used.

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* Paper read at the stated meeting of the Electrical Section of the Franklin Institute, January 24, 1891.

Until recently the only tests made on this cell were by a gentleman in Sioux City, who obtained from cells, of which the dimensions were 5in. by 8in. by 8in., and the weight 34lb. each, a storage capacity of 100 ampere-hours and a "quantity efficiency" of 76 per cent. with a charging and discharging current of about 10 amperes. The real efficiency, or the energy taken out divided by energy put in, was not stated by him.

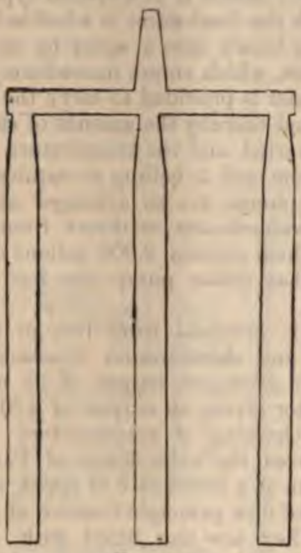


FIG. 5

The cell which I received from Messrs. Bradbury and Stone was the worst which they had on hand, having been short-circuited for hours at a time, and having been allowed to stand with the solution partially evaporated. Consequently the plates were quite badly sulphated, and I did not have sufficient time to get them in first-class condition.

The instruments used were a Weston voltmeter reading to five volts and a Weston ammeter reading to 25 amperes. The test for resistance of the battery, made by the current and potential galvanometer method, gave, as was expected, a rather high result, varying from ·011 to ·016 ohms.

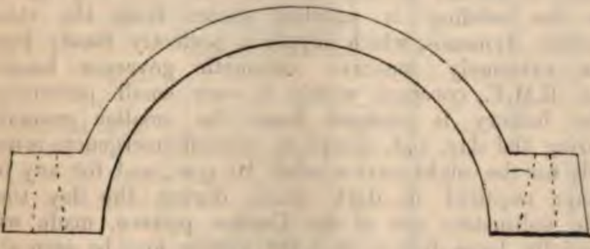


FIG. 6.

The next test was to ascertain whether it would give a current in excess of its normal current for any length of time. It was found that it would give 25 amperes for, at least, one hour. The next test was to determine the capacity and efficiency under different conditions.

The method of testing was as follows:

Discharge the cell at the desired rate till the P.D. was 1·8 volts. Immediately charge at the desired rate reading volts and amperes until charged. Note the duration of charge, and compute the ampere-hours A H and the watt-hours W H. As soon as charged, immediately discharge at the desired rate, reading as before; and compute ampere-hours A′ H′, and watt-hours W′ H′.

$$\frac{A' H'}{A H} = \text{quantity efficiency.}$$

and

$$\frac{W' H'}{W H} = \text{real efficiency.}$$

under the conditions of the test. The result of three tests is as follows:

Average charging current.	Average discharging current.	Ampere-hours taken out.	Quantity efficiency per cent.	Real efficiency per cent.
12·07	15·	65	61	51
11·2	11·2	56	77	65
10·02	10·03	75	75	66

They show, as with any cell, the gain in using low rates of charge and discharge; but besides this they show that this cell is very inefficient at a rate above 10 amperes.

After the first test the cell was left open-circuited for 12 hours, after which 12 ampere-hours were taken out before the P.D. reached 1·8. After a further rest of three hours, six ampere-hours were taken out. This recovery, found in all cells, as was expected, is very much exaggerated in this cell on account of the thickness of the plates, and the cells would, in an installation where the work was intermittent, give results considerably better than is indicated by the table above. In all probability the capacity, efficiency, and rate of discharge would be improved by making the plates thinner.

In the following table I have made a comparison of the different makes of cell as regards storage capacity, weight, and volume. Not having weight and volume of the plates themselves at hand, I have been obliged to use the weight and dimensions of the entire cell. It will be seen that as regards the volume per ampere-hour, it compares favourably with the others, but in respect of ampere-hours per pound it is deficient.

		Ampere-hours per pound of cell.	Cubic inches per ampere-hour.
Accumulators		2·86	4·44
Bradbury-Stone		1·85	4·44
Detroit		2·65	4·63
E.P.S.	Stationary	1·91	7·06
	Traction	2·26	5·53
Julien		2·81	4·33
Pumpelly		3·00	4·85

It is probable that a cell with this plate better designed, and in better condition, would give results much more comparable to the others as regards efficiency, capacity, and discharge rate, while it would surpass many of them in durability, and I hope at some future time to present to the section the results of some tests upon such a plate.

CORRESPONDENCE.

THE LANE FOX PATENTS.

SIR,—I shall be much obliged if you will allow me through your columns to offer a few observations for the purpose of explaining the report of the action of the Kensington and Knightsbridge Electric Supply Co. and the Lane Fox Electrical Co., which appeared in the *Times* of last Saturday.

This report, although accurate as far as it goes, is calculated to convey, to anyone unacquainted with the history of the matter, a very misleading conception of the actual state of the case. Briefly stated, the facts are as follows: The patent in dispute covers the method of electric light distribution now very generally in use, and which is known as the "direct supply system."

This patent was till quite recently held by the Brush Electric Light Co., and was the subject of litigation between that company and the Edison-Swan Electric Light Co. Before, however, the case came into court, a settlement was arrived at between the two companies, whereby the Edison-Swan Co. acknowledged the validity of the patent and accepted a license from the Brush Co. What the precise terms of this license may be I have not been able to ascertain. Suffice it to say that, inasmuch as it raised questions between the Brush Co. and myself, a new agreement was entered into between us, by which the patent was made over to me subject to this Edison-Swan license, the benefit of which was retained by the Brush Co. In this way I became entitled to royalties ensuing from the use of the patent by the trade generally, with the above exceptions. I not unnaturally concluded that the patent having been acknowledged by two such important firms as the Edison Swan Co. and the Brush Co., and that having the strong support of by far the most eminent scientific and legal authorities of the day (including Sir

William Thomson, president of the Royal Society, Dr. Silvanus Thompson, Prof. Perry, Mr. W. H. Preece, Mr. Latimer Clark, Sir Richard Webster, Mr. Fletcher Moulton, and many others), it would be generally acknowledged by the various infringers without any further dispute. Accordingly a limited company was formed, with the nominal capital of £100, for the purpose of holding the patent and of apportioning certain interests therein. Instead, however, of honourably accepting the situation, a movement was started in the trade, at the instigation of the Kensington and Knightsbridge Co., for organising an opposition to the patent. After all our conciliatory overtures to this trade combination had failed, an action was started against the Kensington and Knightsbridge Co. in the joint names of myself and my company, and for this action we retained the services of the Attorney-General, and Mr. Moulton, Q.C., for both of whom I had a general retainer of long standing.

Now the Kensington and Knightsbridge Co., holding also a general retainer (though of long subsequent date to my own) for these same counsel, claimed their services against us, because, according to the rules which govern these matters, my prior retainer was invalidated by the fact of my company being made party to the suit. The consequence was, that in order that we might continue to have the services of these counsel the original action had to be withdrawn, and a new one instituted in my own name alone. These facts will explain how it came about that we were placed in the rather curious position indicated in the report of the proceedings before Mr. Justice Stirling.—Yours, etc., St. G. Lane Fox.

66, Victoria-street, April 28.

SECONDARY BATTERIES.

[TRANSLATION.]

Sir,—In reading in your esteemed journal, the *Electrical Engineer*, of 24th April, 1891, the paper by Mr. J. T. Niblett, on "Some Recent Improvements in Lead Secondary Batteries," read before the Physical Society of the Glasgow University, on 13th January, 1891, I notice, on p. 418, the description of an indicator of the state of charge of accumulators due to Mr. Magnus Volk, based on the use of a tube occupying practically the whole depth of the liquid.

Permit me to claim the priority of this invention, for which I have taken a patent in England on August 28th, 1890, bearing the number 13,522.

My instrument was presented before the Société Internationale des Electriciens on November 5th, 1890, and described in *L'Electricien*, November 8, 1890, No. 395; *La Nature*, January 10, 1891, No. 919; *Electrical Review*, April 17, 1891; and *Journal* of the Institution of Electrical Engineers, April, 1891, p. 258. Some of these instruments are to be seen in the hands of my friend, Mr. J. A. Berly.

I should be greatly obliged by the publication of this letter in your next issue.—Receive, Sir, my sincere respects,

Paris, April 27, 1891. G. Roux.

NEW METROPOLITAN POLICE BUILDINGS.

The whole of the new Metropolitan Police Offices at New Scotland Yard have been fitted with the electric light by Messrs. Drake and Gorham, as contractors, with Mr. A. A. Campbell Swinton, as consulting engineer. There are about 1,100 lamps at present fixed, and the total number will eventually be about 1,250.

Every effort has been made to render this installation as complete and perfect as possible, and it is believed that every possible contingency which could produce a failure of the light has been provided against and overcome. The engine-house has been excavated in the yard, between the main building and Whitehall, and the whole of the generating plant has been placed well away from the offices. The steam plant consists of three Lancashire boilers by Davey, Paxman, and Co., each 22ft. 6in. by 6ft. diameter, each containing two flues, 2ft. 3in. diameter, with three circulating tubes and Paxman's patent strengthening and expansion joint. The heating-surface of each boiler is 480 square feet, and the three boilers are capable of evaporating from 6,000lb. to 8,000lb. of water per hour.

The chimney contains 12 square feet in sectional area and is carried up to a height of 80ft., the bottom 40ft. being lined with firebrick. The steam is conveyed to the engine-room by a duplicate system of steam-pipes divided by nine valves, which enable any length to be cut out of circuit as required, and provides for the continuation of the working in the event of a failure of the steam-pipe at any point.

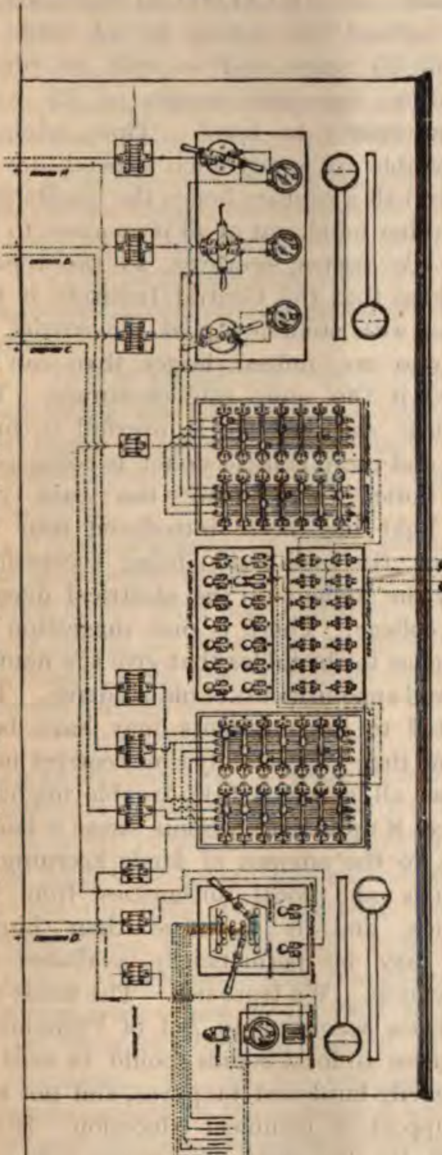
The feed-water heater is of a special type, consisting of a tank into which the feed-water is admitted by a ball valve, the water being blown into a spray by the exhaust steam from the engines, which enters immediately under the ball valve. A by-pass is provided to carry the exhaust direct to the chimney, and thereby the amount of steam entering the heater can be varied, and the temperature of the water can be regulated from cold to boiling as required. The Worthington steam pumps are so arranged as to draw water from the feed-water heater, or direct from the main feed-water tanks, which contain 2,000 gallons of water, and are so connected that either pump can feed any one of the boilers at will.

The current is obtained from four of the new Parsons steam turbines and shunt-wound dynamos, three of these being capable of giving an output of 35 units each, and a smaller generator giving an output of 120 amperes × 130 volts for the charging of accumulators. These machines differ chiefly from the older forms of Parsons generators, in that they run at a lower rate of speed, and the turbines are on the radial-flow principle instead of parallel flow, as previously. They are also fitted with a new form of variable expansion electrical governor, which secures additional economy at light loads, and is designed to maintain a constant E.M.F. under all conditions. The accumulators consist of 106 cells, capable of discharging at a rate of 120 amperes for nine hours for the supply of 200 lamps of 16 c.p. each. The main distributing switchboard is placed 2ft. 6in. from the wall, and doors provide access to the back of the partition, so that all the connections at the back and front can easily be inspected at any time.

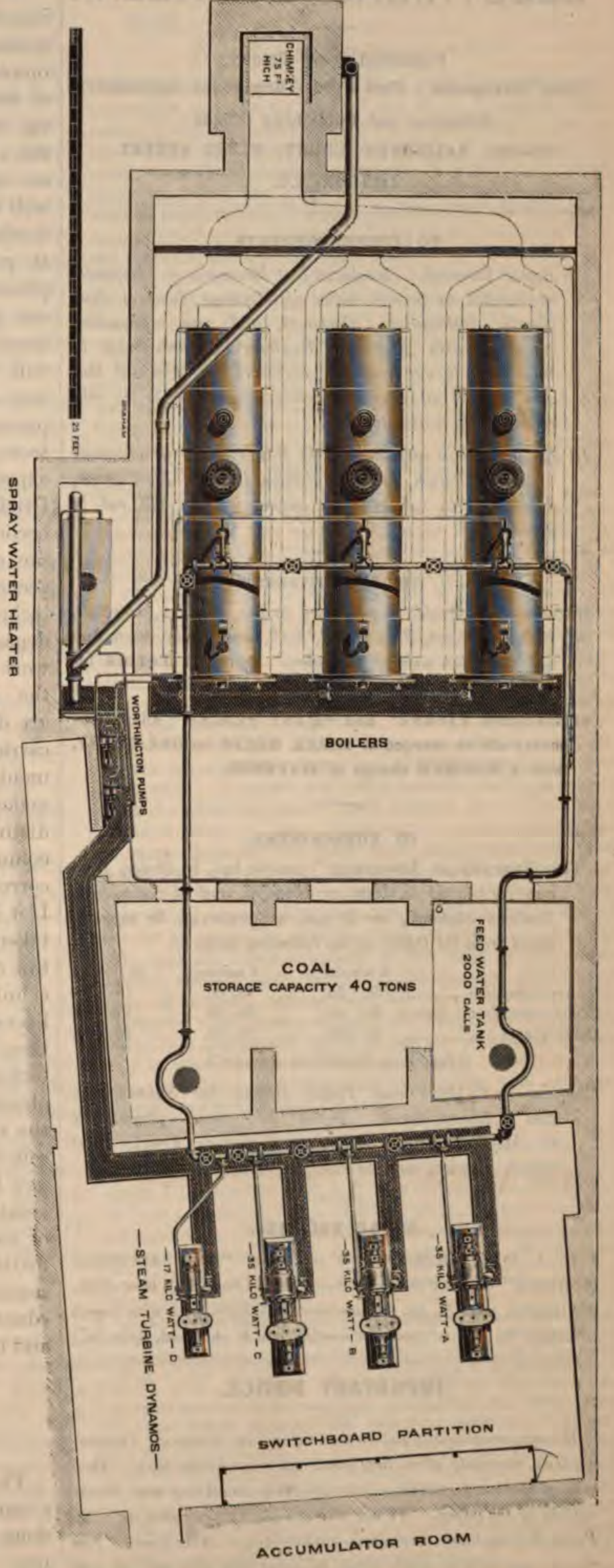
The lamp circuits from the main building are brought to a special distributing-board, fitted with cross connections and Drake and Gorham patent ring contact switches, the design permitting both positive and negative connections to be shifted from any one of the sources of generating power to another instantaneously. The ordinary lighting for the building is supplied direct from the steam turbine dynamos, which supply a perfectly steady light, the extremely sensitive automatic governor keeping the E.M.F. constant within a very small percentage. The battery is charged from the smaller generator during the day, and, except in cases of emergency, is used only for the night service after 10 p.m., and for any few lamps required in dark places during the day time. The voltmeters are of the Cardew pattern, made with specially large dials so that the voltage may be seen at a glance from any point in the engine-room.

The wiring of the main building has been carried out so as to obtain the greatest security and immunity from failure of the light, a number of small mains being run from the distributing-board in preference to large conductors. Every alternate lamp throughout the building is supplied from a different circuit, so that, in the event of a breakdown, only half the lights would be extinguished. Throughout the passages the casing is let in flush with the face of the plaster, so as to render the conductors accessible without being an eyesore. The branch conductors are carried to small distributing fuse-boxes, with glass fronts, placed over the doors in the different offices, from which point special vulcanised twin conductors braided with white cotton are carried to each lamp on the face of the concrete ceilings, and supported with eyelets bushed with ebonite. This arrangement enables the position of the light to be shifted at any time without difficulty, and provides one solution of the extremely difficult problem of running the branch wires in modern fireproof buildings in which no lath and plaster is used. In order to ensure economy, a separate switch has been provided for every individual lamp throughout the rooms and offices.

The generating plant also provides electrical power to the printing office, where the police reports and notices are now all printed by a machine worked by an electromotor. New Scotland Yard is, it is believed, the first Government office lighted entirely and exclusively with the electric light. The whole installation is now practically complete and the new illuminant is giving general satisfaction to the occupants.



Plan of Distributing Board.—Metropolitan Police Offices.



Plan of Engine and Boiler Room.—Metropolitan Police Offices.

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CITY AND GUILDS OF LONDON INSTITUTE.

The "Report to the Governors" has just been issued. Like all reports, its tenour is very satisfactory or the opposite according to the prevalent opinion in the mind of the reader. The total amount of the donations and subscriptions to the funds of the institute since its foundation in 1878 reaches the stupendous total of £352,542. 19s. 6d. There are many who consider this money has not been well spent. Whatever the view taken, however, we would point out that a true balance-sheet cannot be at present made out. If £1,000 be expended in planting an orchard, the return is not made in one year or in 10 years, and so with an educational foundation, the real results of its work will come but slowly to hand. Thus, while it may be impossible to justify such expenditure by present results, half a century hence the results may seem, on the other hand, out of all proportion to the expenditure. To return, however, to the report. Briefly, it tells us that the Central Institute is fast becoming filled with students; that the entries for the current year are, indeed, larger than can be accommodated if the same rate continues. The technical college at Finsbury is overfull in most departments, and there is little doubt is doing good work. We notice that during the past year the electric light has been introduced into the art department, the installation being successfully carried out by the students in the electrical department of the college. There is one suggestion to make in reference to the tables that give the names, distinctions, and appointments of old students. The column devoted to appointments may have been correct at some time; it certainly is not correct now. If it is given at all, surely a little trouble might be taken to correct it up to date. Some stress is laid in this report as to the amount of funds accruing to county councils and local authorities from the licensing funds, and it is more than hinted these funds may be permanently available for technical education. We trust not. The funds are obtained by levies according to Act of Parliament, the amount given to local bodies should be used to relieve the heavily-burdened taxpayer, and not as a new tax in support of technical education. It is a great pity that Mr. Bousfield, who writes this part of the report, had no better appreciation of this matter than is shown by his crude and ill-considered remarks. If we are to have State-aided technical education, impose a tax directly for that purpose, and not tax the community in an indirect way.

THE CITY LIGHTING.

The annual report of Colonel Haywood to the Commissioners of Sewers sums up what has been done during the past year as regards the City lighting. That portion of the report dealing with electric lighting commences with a sentence which we trust will in future fail to find a place in the report. It reads as follows: "During the past year none of the public ways of the City were lighted by electricity." The report tells us what we all know, and yet are apt to forget—that the three parts into which the City was divided for electric lighting purposes are in the hands of the contractors. On January 28 the tender of the Laing, Wharton, and Down Construction Syndicate for lighting one part of the City, on the same terms as previously agreed to by the Brush Company for another part, was practically accepted. On February 28 a modification of the Brush Company's tender was agreed to. On March 18 certain modifications in the above contract—viz., for the central and eastern districts—were finally agreed to. These modifications are important, and have not hitherto been set forth in detail in the technical papers. They are as follows:

"That the company have wayleave in subways for private supply, notwithstanding the contract for public supply may have been determined.

"That the private supply be exclusive for 21 years, whether the contract for public supply be determined or not.

"That as regards the remedy of defects found on inspection, the penalty be not enforced if the work of repair be commenced within 24 hours, and be proceeded with diligently to the satisfaction of the engineer.

"That as regards the sliding scale, 7½ per cent. per annum be allowed for depreciation (on the capital sunk in the plant and machinery), and 5 per cent. per annum (of the profits available for dividend) for a reserve fund, until such fund amounts to a quarter of the paid-up capital.

"That though the purchase of the undertaking for public supply at 21 years be under the Act, the purchase of the private supply at 21 years be by agreement or arbitration, the purchase of either at 42 years to be under the terms of the Act."

On the 29th April consent was given to the applications for provisional orders by the above-named companies. The contracts with the companies were signed on the 19th May and 28th May last, thus closing that portion of the preliminary operations. On the 7th October it was agreed to invite tenders for the lighting of the western district. The tenders were received on November 28 and on December 12; that of the Brush Company was accepted, and a provisional order has been applied for. Such is the year's historical record.

Utilisation of Niagara.—A telegram from New York runs: "English capitalists, who are said to own the electrical works at Deptford, have made a 'deal' with the Niagara Falls Commissioners, and they will set to work to utilise the power of the falls to generate electricity. The great strength of the falls will afford an enormously high voltage for the motive power for lighting all the manufacturing towns within a radius of 150 miles. They have deposited 20,000dols., which will be forfeited if the work is not started by March, 1892. They will pay for the privilege 25,000dols. a year for the first 10 years, rising to 35,000dols. in 20 years."—*Pall Mall Gazette.*

THE ELECTRIC LIGHTING OF PUBLIC BUILDINGS: WITH SPECIAL REFERENCE TO THE ATHENÆUM ELECTRIC LIGHT INSTALLATION.[*]

BY PROF. JAMIESON, M.I.C.E., F.R.S.E.

Having been engaged of late as consulting engineer in connection with the electric lighting of the Glasgow Athenæum, it was suggested to me that a short paper descriptive of the work as carried out might be of interest to the members of this institution especially, if a few hints were given regarding the general principles which regulate the various requirements of such installations, as well as actual data of the results obtained. Although a great number of the towns in this country have obtained provisional orders for the purpose of supplying stipulated districts with the electric light, yet many public buildings, such as theatres, hotels, clubs, libraries, concert halls, etc., have preferred, and no doubt will continue, to run their own installations.

Unless the building to be lighted is one about to be constructed, wherein due provision can be made to readily accommodate all the generating plant without cramping, the engineer, as a rule, finds himself confined in space and position to some underground cellar. Under these circumstances, he is often compelled to adopt arrangements which he would otherwise have avoided.

The first point to be ascertained is the number and candle-power of the lamps. In order to obtain this, the engineer has to take into consideration not only the size of the respective rooms, but their special requirements.[†]

The rule which we have adopted in the Athenæum for the large newsroom is 1·75 square feet of floor surface per standard candle. This gives an exceedingly good light on the reading-desks; in fact, it is equivalent to about three standard candles at 1ft. distance from the centre of the raised daily newspaper stands. These "Sunbeam" lamps are most decidedly preferable to arc lamps, since they cast no objectionable shadows, give no hissing noise, and require no attention from their first instalment until they give way. Whereas arc lamps require daily attention, with the additional cost of fresh carbons, etc. Their life is moreover long.[‡] They do, however, require more power to work them for the same total candle-power than arc lamps (of, say, 600 c.p. actual, or 2,000 nominal Brush type) in the proportion of nearly three to one. Taking everything into consideration, these "Sunbeam" lamps are nearly as cheap as medium-sized arc lamps in the long run, and far more satisfactory for large rooms, where perfect silence, freedom from blinking and shadows, as well as artistic appearance, are of importance. For ordinary classrooms, chessrooms, and offices, 16-c.p. lamps are preferable to 8-c.p. ones. Eight-candle lamps may be good enough for bedrooms, and for cabins on board ship, but they compare so unfavourably with our good Scotch gas lighting that we feel convinced the standard at present adopted in London of 8-c.p. lamps will not be tolerated here except under special circumstances. The 16-c.p. lamps in the Athenæum classrooms, etc., are placed about 7ft. from the floor, and an average of 64 square feet of floor surface per lamp, or four square feet per candle, has been allowed. On the students' desks this gives an illumination of from ·8 to 1 standard candle at 1ft. distance.

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[*] From the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland.

[†] Where you have to light a large area, such as a newsroom or art-room, then it is undoubtedly advisable, both as regards expenditure of power and first cost, to use a few "Sunbeam" lamps of 150 c.p. to 300 c.p. in preference to a great number of 16 c.p. or 8 c.p. lamps. In illustration of this statement, let us consider the case of the newsroom in the Athenæum, which is 75ft. by 28ft. Before we had to deal with the installation, 40 lamps of 16 c.p. each (equal to a total of 640 c.p.), requiring 24 amperes at 115 volts, were installed at, say, a cost of £1. 10s. per lamp, or £60 total for the lamps, wiring, and fitings. This gave a most unsatisfactory illumination, whereas these 40 lamps have been replaced by eight "Sunbeams" of 150 c.p. each, requiring exactly the same power, and at a cost of £3 per lamp for the lamps, wiring, and fittings, or £24 total. These produce a light equivalent to 1,200 standard candles with most satisfactory results.

[‡] The eight "Sunbeams" in the newsroom of the Athenæum have been lighted for about 1,600 hours, and are still giving satisfaction.

Some may think this excessive illumination, but when you are to adopt a good thing you may as well do it thoroughly. Of course, in the case of other rooms and passages, 6 to 12 square feet of floor surface per candle will suffice according to circumstances.

Having thus ascertained the total number of lamps of each kind that are required, the next thing to consider is the voltage, or electrical pressure, at which the lamps are to be worked.

A very common electrical pressure is that of 100 volts. In the case of the Athenæum installation we adopted 110 volts, since that was the pressure in the original installation. Of course, as the lamps get older, the carbon loops get thinner, and consequently their resistance increases, therefore we have to gradually increase the pressure to 115 volts as circumstances may require. The current necessary for each size of lamp partly depends upon the voltage at which they are to be worked and the efficiency of the lamps.

We find from actual measurement that 16-c.p. Edison-Swan lamps at 110 to 115 volts require 0·6 to 0·7 ampere each, and the 150-c.p. lamps 3 to 3·5 amperes, whilst the 300-c.p. lamps take 5·5 to 6 amperes, according to the length of time which they have been in use. With this data at hand it is easy to calculate the total watts and electrical horse-power required from the dynamos if we add the loss of power spent in the cables and leads.

Table I. in the appendix gives full information regarding the calculated and actual power expended in the Athenæum on each circuit and on the whole installation.*

Having found the total electrical horse-power, the next question comes to be, what percentage is this of the brake or of the indicated horse-power? In order to arrive at these percentages, it is necessary to know the combined commercial efficiency of the dynamos and prime motor.

The electrical efficiency of good dynamos—*i.e.*, the ratio of the

$$\frac{\text{electrical “output}}{\text{Total electrical power generated}}$$

may be taken as ranging from 85 to 95 per cent. From the data given elsewhere it will be observed that at full load two of the Athenæum dynamos, Nos. 2 and 4, used for lighting direct, have an electrical efficiency of 92 per cent., and at ⅔ load 91 per cent., whereas the other two alternative-wound machines have only an efficiency of 85 per cent. at ⅔ full load. We knowingly sacrificed a certain amount of efficiency in the latter case to accomplish the twofold object of lighting the lamps direct, and of being able to charge the accumulators when required.

Some of the efficiencies which an electrical engineer has to deal with in practice, and to which we have added the efficiencies obtained in the plant under consideration, will be found at the end of this paper.†

In the preceding list of efficiencies the dynamos are driven direct from the engine crankshaft. If belting or counter-shafting were adopted the combined commercial efficiency of the engine and dynamos would be much less, and often does not exceed 60 per cent. of the indicated power of the engine or other prime motor. Of course, with large slow-speed compound Corliss engines the mechanical efficiency of the engines themselves may reach higher values than the above; but then the belt or rope drive and the counter-shafting absorb a very considerable amount, so that it is a safe rule, and one which has been by far too seldom adopted—viz., to consider the electrical output as only equivalent to 50 per cent. of the indicated horse-power. By so doing a margin may be left for contingencies or extensions, without unduly forcing everything up to its theoretical limit.

The type of boiler to be adopted largely depends upon the space at the disposal of the engineer. Where the space is unlimited, then Lancashire boilers, with Galloway tubes, are both economical and easily worked. But where the maximum power has to be got into the minimum of space, then recourse must be had to tubulous or water tube boilers, or to boilers of the locomotive or dryback tubular type. In the Athenæum we have two 60-h.p. boilers of the latter class, made by Messrs. L. Burnet and Co.

In public buildings, where the supply of water is taken from the street mains, it is absolutely necessary to have a storage tank, in order to guard against the event of the supply being cut off. In the Athenæum we have a 1,000-gallon tank sunk in the engine-room floor, with 2in. and 1in. supply pipes connected to two distinct street mains. The feed-pumps should also be in duplicate. In the Athenæum we have two of Carruther and Co.'s direct-acting duplex pumps, one of them being extra large, so that by working it slowly at about 25 strokes per minute the water level in both boilers is maintained constant with a full supply of steam. These pumps can act quite independently of each other, and they deliver direct from the tank to either boiler, or through the feed-heater as required.

A very important matter is that of having all pipes and flues which have to transmit steam, water, or gases, extra large and with very easy bends. Right-angled bends and throttled passages check the flow of these fluids in a most decided manner. The whole of the pipes in the Athenæum installation were made with this principle kept well in view. The large new flue and chimney are of extra size, and afford an excellent natural draught of 1in. water pressure, but in order to comply with the request of the local authorities to make less smoke, we found it advisable to introduce Meldrum's patent forced draught, which gives satisfaction and keeps the tubes of the boiler clean. This form of forced draught consists of an air-tight ashpit front, with two very small steam jets, which play into two conical cast-iron pipes, extending about three-fourths along and underneath the firebars, thus inducing a draught of from 1in. to 2in. water pressure, and keeping the fuel at the back of the fire in a high state of incandescence.

Radiation of heat from boilers and steam-pipes should also have the most careful consideration of the engineer. Where this is neglected great loss of heat takes place, and the engine-room is rendered uncomfortably warm. This may to a large extent be overcome by covering all heat-radiating surfaces with a sufficient thickness of good non-conducting material. In the Athenæum Messrs. William Duff and Co. have covered every necessary part of the boilers, flues, water heater, and steam pipes.

The class of engine to be adopted also depends upon the space placed at the disposal of the engineer. Where the space is unlimited, then undoubtedly a slow-speed compound condensing engine of the Corliss or other quick and early cut-off type is to be preferred. Their efficiency is higher than that of any other class of engine, for they can be run at from 15lb. to 16lb. of steam per hour per indicated horse-power; whereas, high-speed, direct-acting, non-condensing, compound, or even triple expansion engines are seldom worked under 25lb. of steam per hour per indicated horse-power.*

The stresses, wear and tear, and liability to break down of these high-speed engines are also greater than in the case of the lower speed type just alluded to. We must, however, pay tribute to the skill and care which have been brought to bear of late, by various firms both at home and abroad, and notably in this city by Messrs. Alley and M'Lellan, in perfecting and adapting these high-speed engines to suit such circumstances as we had to contend with in the case of the Athenæum, where the space at disposal was so very limited that an eminent English firm refused to tender, because they considered that the necessary power and plant could not be introduced.

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* It may be of interest to some of the members who have not studied electrical engineering to know that the watt is the electrician's unit of power, or activity—*i.e.*, rate of doing work. And that

Watts = Electrical pressure × current,
or that Power in watts, $P_W = E \times C$.
Also that Electrical h.p. $= \frac{\text{watts}}{746} = \frac{E \times C}{746}$.

In the eighth edition of Munro and Jamieson's Pocket Book, tables are being inserted where the watts and electrical horse-power can be found for any voltage from 45 to 3,000, and any current from 1 to 700 amperes, which will save electricians much time and trouble in making the above monotonous and awkward calculations.

† In the case of the Athenæum dynamos, the commercial efficiency is taken as the mean of the electrical efficiencies—viz., $\left(\frac{92\% + 85\%}{2}\right) = 88{\cdot}5\%$, since, in reckoning the efficiency of the engine, the armature was driven at its normal speed, but without nerating any current.

* This is under the ordinary conditions of daily work, although we have heard of special test trials in which the consumpt has been recorded as under 23lb. of steam per hour per indicated horse-power.

(To be continued.)

REGULATION OF CONSTANT-CURRENT GENERATORS.*

BY ALEX. DOW.

(Concluded from page 416.)

I have not overlooked, in preparing this paper, the effects due to the induction of currents in the field windings by the armature. We must not forget that induction works both ways; that the inducing coils are subject to back induction from the currents they induce. This effect is very marked in separately excited alternators, and produces peculiar results. I omit the matter intentionally, as not absolutely necessary to my main subject. Then I could explain armature reaction in another way by describing the free poles of the field and armature surfaces and their induction of poles of opposite sign on adjacent surfaces. But I want to adhere to the simple conception of the magnetic circuit. These other effects can all be expressed as qualities of the circuit, and do not oppose its conception as I have drawn it. And, moreover, my diagram is not necessarily an imaginary one, for you can get just such a diagram by the use of iron filings from an actual dynamo.

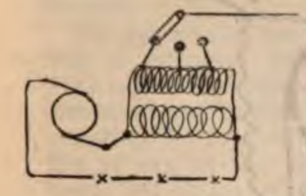
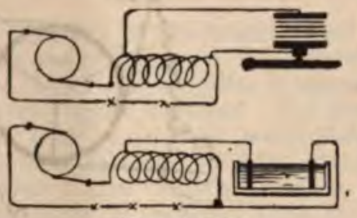


FIG. 4.



FIGS. 5 AND 6.

Please remember when we come to examine regulation by changing the strength of field, that this armature reaction, or lengthening of the magnetic circuit, is least when the field magnetism is strong relatively to the armature, and greatest when the armature magnetism is stronger than the field. I want you to notice that if the field is weakened by some external cause the armature immediately has more reactive power and weakens it still further. And please note also that if the armature polar axis is carried forward by any cause such as the displacement forward of the brushes, this change will lengthen the magnetic circuit. We are familiar in constant-potential work with the rule that the lead necessary to be given the brushes depends on the displacement forward of the interfield polar axis. This rule is reversible, for the position of the axis depends on the lead given to the brushes.

The most familiar regulators of the field-changing class are those in which an adjustable resistance is connected in shunt to the field winding of a series dynamo. The adjustable resistance may be a rheostat of the conventional type, Fig. 4, with a moving contact lever, or it may be a stack of carbon plates, Fig. 5, the resistance of which will be reduced as they are pressed into more intimate contact with one another. Or it may be a trough containing liquid, Fig. 6, with electrodes which can be moved toward one another or immersed further into the liquid to get more surface contact. All of these are in everyday use. We notice that wherever they are in successful use, the variation of the resistance is controlled by a small relay in the main circuit and that the heavy mechanical work of the device is performed by magnets in a local circuit, or by the power driving the dynamo. This use of a sensitive relay is necessary to accurate regulation. It eliminates many errors, such as those due to heating of wire or carbon resistances, to polarisation and change of density of a liquid resistance. The requirement for good, practical regulation of an arc circuit is that the relay shall be more sensitive than the arc lamp.

It is frequently so delicate that it responds promptly to a variation of current of ¼ of 1 per cent.

There are dynamos widely used in which the function of the control relay is assigned to a magnet, which has also considerable mechanical work to perform, and is necessarily less sensitive as its duties are increased. Most of these dynamos obviously suffer in their regulation from that cause.

To come back to diagrams. Another way of varying field magnet strength is shown in Fig. 7. It is in use on the Hochhausen dynamo and motor, and is quite accurate when the field is divided into many sections. A similar arrangement where the field coils, instead of being altered in number, are subject to permutations and combinations that vary the number in series, is in use on two systems of series-wound street-car motors. This does not work so well as the Hochhausen plan because it is limited to a few gradations, and it is usually combined with a resistance called an "easy-starting coil" to make it less jerky in its operation.

Either of these methods works first to change the ampere-turns in the field coils. The shunt arrangements change the amperes and the commutator arrangements change the turns. That means a reduction of magneto-motive force, but the magneto-motive force in the armature remains the same; its amperes and turns are constant, and so there is armature reaction. The polar axis of the interpolar area shifts forward and the brushes have to follow to stop sparking. This very carrying forward of the brushes shifts the interpolar axis still more because it shifts the armature axis; and so their actions continue till equilibrium is reached. Now we have as a result a longer magnetic circuit than before regulation began, more magnetic resistance as well as less magneto-motive force; therefore a double reduction of the magnetic flux or field strength.

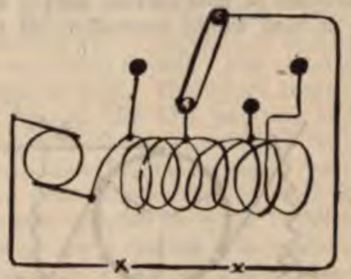


FIG. 7.

Some of you may have been accustomed to think of the reduction of E.M.F. under the field regulation as due only to change of exciting current. The changes of lead under such regulation should indicate the actual process to an observer, but not one published description takes account of anything but the fall of field current. If you wish to understand clearly the process, I suggest that you put an ammeter in the field circuit of your dynamo. You will possibly find a reduction of E.M.F. of 90 per cent. to follow a reduction of only 45 per cent. in the exciting current.

We come now to consider that class of regulators which operates by moving the brushes of a closed-coil armature. There is a marked difference in this method as applied to open-coil armatures, and we will consider now only those having Gramme or Siemens windings. There are a number of dynamos in this class. Some regulate well, some miserably.

The most common explanation of this regulation is by the well-known "diagram of potentials," showing that near the neutral point the brushes are on the diameter of maximum difference of potential, and that 90deg. distant they would find a diameter of equi-potential, and of course that any desired intermediate potential difference can be had on the proper intermediate diameter. And you can, by using a voltmeter—not the brushes—get just a diagram off any of these machines, so, of course, the explanation is complete. But I have harboured for a long time the wicked suspicion that this explanation didn't explain; even though it was put forward with a great big diagram to illustrate it right in this club. And this was what aroused my suspicion. I looked at the diagram and saw that if I rocked forward those brushes 45deg. or 50deg., I would get just half the maximum potential. Then I looked at a machine and found that if I rocked forward the brushes 45deg. or 50deg., I did not get any potential at all. Then I looked at more machines, and more and more of them, and they all had this utterly unjustifiable departure from the diagram which they were bound to live up to. And so my suspicion grew.

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* Paper read before the Chicago Electric Club, April 6, 1891.

Now I do not operate an arc machine of this kind, and so I could not apply the practical methods of investigation, but there fell into my hands lately a 400-ampere incandescent machine, which had the same characteristic of a rapid fall in voltage as the brushes were rocked forward, and the same marvellously sparkless commutator that the best of these arc machines possess. I said the best of them; they are not sparkless as a class, and some of them can eat more copper than any open-coil dynamo.

So I went to work on my 400-ampere machine with a voltmeter, and I got a beautiful potential curve. Then I calculated the position which would give me 5 per cent. reduction in voltage, rocked the brushes forward, and got a 10 per cent. reduction. And so it was in every position in which I could try it.

Then I got hold of a series-wound dynamo and ran it on a resistance. I rocked the brushes backward and forward as far as the spark would permit, and found that I could vary the current from maximum about 40 per cent. downward. Then I tried what effect varying the field current would have in comparison with changing the lead, and I found that variation of field current simply wasn't in it; a little change of lead would neutralise all the variation I could control.

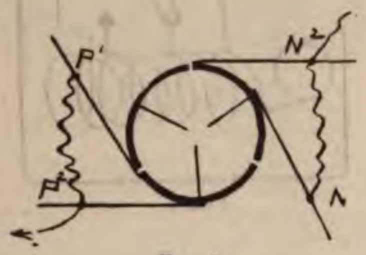


Fig. 8.

Here were two machines that had but one thing in common with the arc dynamos—namely, a strong armature compared with their fields. And they show the same quality of regulation by brush rocking as did these special arc dynamos. My suspicion was becoming a theory at a rapid rate.

Then I bethought me once more of all the arc dynamos I had ever known that regulated in this way. I singled out two that I knew could be adjusted to a fraction of an ampere, over a long range of E.M.F. These two had Gramme armatures—the type that gives the strongest magnetic reaction. They had also fields of small value compared with the armatures. And I bethought me of two others which I knew would not regulate within 10 per cent. at low E.M.F. These two had armatures of a different type which gives the least magnetic reaction, and had massive fields; in fact, had fields of a pattern which has proved admirable in controlling variation of lead in incandescent work. I remembered also that these two carried a bad spark at small loads. Also, that one of them had practically been driven out of use by that spark, and that the other, which had a splendidly-designed commutator, and so could stand the spark, had been improved by changes tending to weaken its field.

And so I formulated the theory that regulation by brush rocking depended on armature reaction, and that consequently the essential condition to success under this method was a magnetic circuit in which the armature magnetism had large value in comparison with the fields. I will try to verify that theory when I get a good opportunity. In the meantime it is up for discussion.

Now there is one more method of constant-current regulation in use, that cannot be left out of any paper on this subject. It is regulation by changing the effective length of armature conductor, and its sole representative is a well-known open-coil dynamo, the Thomson-Houston. You are doubtless familiar with the brush arrangements of this peculiar machine, and know that its regulation of E.M.F. is by a device which short-circuits the armature. But to assist your remembrance I have here two diagrams, showing the full load, Fig. 8, and minimum load, Fig. 9, positions of the brushes and their contact with the segments at these positions. Notice that in the minimum position the armature is absolutely short-circuited from brush to brush during half the revolution. That is, it is short-circuited six times in each revolution and each time during 40deg. of its movement, a total of 180deg. This period of short circuit is gradually reduced in its duration, although it still occurs six times per revolution, until the full load position is reached, when it is almost nothing. It would be absolutely nothing if it were not for the spark. The metallic contact is broken, but the spark under the tip of the secondary brush has conductivity, like any other electric spark, and so gives a momentary short circuit.

I have defined this regulation as changing the effective length of armature conductor and you see the reason of the definition. Of course, the actual length of armature conductor is unchanged, but the effective length is, in virtue of the fact that the armature conductor is closed on itself and forms a local circuit by itself, having no connection with the circuit under regulation.

A similar method is applicable to any open-coil machine which "cuts off" the coils passing the neutral point. If an active coil be thrown into parallel with an idle coil, the two form a local circuit and are so removed, from the circuit under regulation. This method is somewhat unmanageable as a device for adjusting output to load, but can be and is employed to get special results in the design of open-coil commutators.

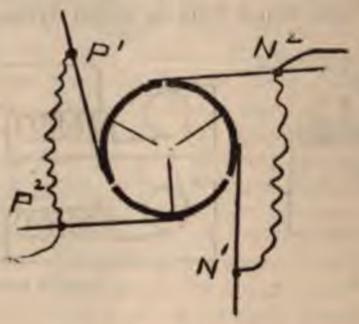


Fig. 9.

How to consider the internal process of regulation in the dynamo which short circuits its armature.

The actions following the short circuit of active armature coils are complex. We expect the most noticeable to be the development of a tremendous current in the short-circuited coils, with great heating, and our experience with short-circuiting of individual sections of armatures would lead us to predict the early destruction of the winding from this cause. And that is just what many electricians do predict. The facts do not bear out the predictions.

This armature, though not noted for exceptional long life, makes a very good showing in that respect, and its burning out when it does occur is not attributable to the excessive heating of its windings under regulation.

The enormous short-circuit current begins to develop, but meets reactions which arrest its growth. To consider these, a short circuit occurs six times in a revolution. That means, in a dynamo running at 800 revolutions, that this abnormal current is started and arrested 4,800 times per minute. In other words, that it is a periodical current with a periodicity of 80. This periodical current is developed in two coils of great length; of many convolutions; wound on an iron core; in other words, in a circuit of great inductance, and so being subject to the laws that govern periodical currents in inductive circuits—just the same laws that govern alternating currents in converters—it attains a very small mean value and has proportionally small heating effect.

If we stop the consideration of the subject here, we could understand that the coils so short-circuited would be little more likely to heat than if carrying only the regular current; but there are further reactions to be considered to understand the operation of the regulating device. There is a direct reduction of the field of force, due to the cutting off of the exciting current by the short circuit at the brushes. The armature is closed on itself and sends no current to the field coils, and this cessation of magneto-motive force implies a cessation of magnetic flux—"a loss of field." The field grows gradually, returning its accumulated energy to the circuit which supplied it in the shape of an "extra current" in the same direction as the exciting current, and this extra current passing to line occupies the time between armature currents and makes the line current continuous. It is undulatory, not intermittent, as it would be but for the discharge of the field magnets. The process is reversed when the short circuit is removed from the armature. The armature current has risen above normal, and carried up the armature magnetism with it. This accumulated energy would pass to line as a sudden extra current, but is retarded by the partially discharged field magnets, and expends itself in carrying their magnetism up toward its normal value. This is a good example of the "steadying effect" of a magnet on a pulsatory or intermittent current. And there is still another cause reducing the induction. We have seen that there is a slight increase in the armature magnetism and also a decrease in the field magnetism. That means that the equilibrium of polarity established between the armature and field in their normal relation is now disturbed. We have outward evidence of this in the necessity for moving forward the secondary brush of each pair in order to minimise sparking—the lead has obviously changed.

We observe that the designers of the dynamo found it well to introduce some complication on this account. They move both brushes of each pair and these in opposite directions, and for different angular distances. The short-circuiting for regulation could have been accomplished just as well by the rocking backward of the primary brush, but change of lead results therefrom, and so to keep on the point of least spark the secondary brush has to go forward. And we have seen earlier in this paper that any forward change of lead signifies a lengthening of the magnetic circuit, and a consequent reduction of the field value. Thus the regulation is effected not only by removal from circuit of the conductors cutting lines of force, but also by actual reduction of the number of lines of force in the field. And, further, we see that this reduction of field is due both to a decrease in magneto-motive force, in that the exciting current becomes intermittent; and to increased resistance of magnetic circuit in that the resultant polarity of the armature is displaced forward, virtually lengthening the path to be taken by the magnetic flux.

The same reduction of field that affects the working circuit influences also the local circuit of the armature, and aids in preventing any injurious increase of current or heating of the short-circuited coils.

It will be asked why the operators of these dynamos avoid running them on few lamps and what cause there is for the frequent statement that they heat when worked on a minimum load.

The explanation is simple if we again consider the action of periodical or intermittent currents.

We observe that as the load decreases the short-circuiting becomes more lengthened, and the currents delivered to the field coils become more markedly intermittent. The coils are wound on an iron core, and it is to the iron we must look for the heating. It is in exactly the same relation to the field coils as are the secondary winding and iron core of an induction coil to its primary, and it is not laminated as is the core of the induction coil; nor is it, like the secondary, provided with an external circuit for the utilisation in external work of the currents developed in it. It is to these induced or Foucault currents that we must attribute the heating of the dynamo at short loads.

My experience with this machine is that the heating seldom becomes objectionable in practice.

If it were necessary to eliminate it, lamination of fields and an additional lamination of armature would be the obvious remedy.

I am not sure, though, that the cure would not be worse than the disease.

The last point I can take up in this paper is the influence which the work a dynamo is doing has upon its regulation. Of course the work of a dynamo can be expressed as so many watts, no matter how the current is employed, but practical men recognise that certain classes of work, though they may not exceed in watts certain other classes, are much more severe on the machine and trying to the regulation. I have spoken of the difficulty of regulating with series motors on a constant current dynamo. That is the meanest work you can put a machine to, and the fact that so many lighting stations have developed a paying and satisfactory business in supplying current to such motors is a big compliment to American electric light men. Just think of the changes a dynamo has to meet when it is in circuit with a motor which occasionally holds up a runaway by backing its brushes and acting as a generator.

The motor circuit is notoriously the hard one, but many practical men have noted that there is difference in facility of regulation with different arc lamps in circuit. Thus the differentially-wound arc lamp, with a strong magnet in the main circuit, is an easy lamp to regulate for. The discharge from the series magnet helps the dynamo during a momentary overload, and so does the shortening of the arc. But the shunt-wouud arc lamp—the so-called "open-circuit" lamp—is just the reverse. The discharge from its magnet goes through its own arc, and for all small changes of current its action is to lengthen the arc for a decrease and shorten it for an increase, and so put more work on the dynamo regulator. The series incandescent lamps behave in a similar way. A circuit with a large proportion of these is always hard to pull. For instance, the machine flashes and loses its field. If only arc lamps were in circuit they would drop to the idle position, and the dynamo would practically be short-circuited and build up its field again at once. But the incandescent lamps get time to cool, and their resistance increases so much that the dynamo has a circuit bady adapted for quick building up. I have seen it necessary to cut out the loop containing the series lamps in order to get a field quickly, although the dynamo picked them up at once when they were switched in after the arcs had lighted.

In concluding, I would suggest to you the adoption in your studies of the expression I have used for the armature reaction effect—namely, lengthening of the magnetic circuit. I submit that the expression has the following advantages: It explains the observed effect; it conforms to the now generally received law of the magnetic circuit; it can be expressed in terms of magnetic resistance, just as can the effect of any other change of magnetic circuit; it admits readily of graphic illustration; and can be shown by an iron filing card taken from an actual dynamo.

The terms armature reaction and cross magnetisation don't fit with the idea of the magnetic circuit. The expression of the effect as so many negative ampere-turns has been employed, but it is confusing to consider a condition as a reduction of magneto-motive force when that theoretical condition is accompanied by an actual increase of ampere-turns. I propose to count all ampere-turns of field and armature as positive, and to express the reduced magnetic flux following distortion of field as due to increased length and therefore resistance of the magnetic circuit.

LONDON COUNTY COUNCIL.

The following is the report of the Highways Committee of the London County Council, April 23, 1891:

Subways.—1. We have received a report from the engineer with reference to a fire which occurred in the Northumberland-avenue subway on April 1, by which some slight damage was done to wires belonging to the Post Office Telegraphs Department. The origin of the fire cannot be precisely ascertained; but it is supposed that a lighted pipe may have been left in a coat belonging to one of the flushers who used the subway for the purpose of changing their clothes before entering the sewers, or that a sewer lamp may have been left alight in the subway and by some means got upset. The use of the subway by the flushers has now been discontinued. In the course of our enquiries into this matter we have ascertained that there is at present no effective control exercised over the use of the Council's subways; and although the Council, on our recommendation, caused locks to be placed on the entrances to the subways, these locks have not yet been used, owing to the objections offered by the companies and others using the subways, and it is possible for persons to enter the subways without the knowledge of the Council's officials. The Council, on the 19th of November, 1889, made by-laws relative to the use of certain of the subways; and these were subsequently confirmed by the Board of Trade and by the Secretary of State for the Home Department, and came into force in March of this year. As, however, these by-laws cannot be made to apply to all the subways of the Council (from the incomplete powers of the Council in this respect), we have been preparing, and hope soon to submit to the Council, regulations applicable to all the subways. In the meantime, however, we think that as a matter of precaution, and for the protection not only of the subways themselves, but of the pipes and wires therein belonging to the various companies and others, the entrances to the subways should be kept locked, proper facilities being given for authorised persons to enter them when requisite. This step, however, should, in our opinion, not be taken without due notice being given to the companies and others concerned; and we therefore recommend—

> That notice be given to the Postmaster-General and to each of the gas, water, electric lighting, and other companies having pipes, wires, or other apparatus in the Council's subways, that on and after the 1st of June next, the entrances to the subways will be locked, and be kept locked; that companies and others desiring to enter a subway for any purpose, must, except in cases of urgency, which will admit of no delay, give to the Council's chief engineer at least 24 hours' notice in writing of the time at which they wish so to enter; and, further, that all persons contravening the Council's by-laws and regulations relative to the subways, will be held responsible for the consequences.

Electric Lighting—Provisional Orders, 1891.—2. We reported, on the 14th of April, that we had submitted to the Board of Trade on behalf of the Council amendments which, in our opinion, should be made in several electric lighting orders specified in the report; and we have now, for the information of the Council, to state that letters have been received from the Board to the effect that in the Clerkenwell, Islington, Hackney, Woolwich district, Camberwell, St. Luke's, Middlesex, Wandsworth, and Southwark orders, most of the suggested amendments have been made. Those amendments which have not been adopted by the Board do not, in our opinion, relate to matters of very great importance, and we therefore do not advise the Council to further press them.

Notices under Electric Lighting Orders and Acts.—3. We have considered a notice dated 15th April, 1891, from the London Electric Supply Corporation of its intention to lay trunk mains in Cockspur-street, Spring-gardens, Buckingham Palace-road, Lower Grosvenor-place, and Ebury-street. The plans show that the mains will also be laid along The Mall, St. James's Park, which place, however, is not specified in the notice to the Council; and as this is Crown property, the Council has no jurisdiction there. There appears to be no reason for objection to the laying of the proposed mains; but drawings of the junction-box proposed to be placed in Cockspur-street should be submitted for approval before the box is constructed. We recommend—

> That the sanction of the Council be given to the laying of the trunk mains referred to in the notice of the London Electric Supply Corporation, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the works; that the mains, where laid under the footways, shall be kept 2ft. below the underside of the paving, and where they cross the carriageways at the same depth below the concrete, or if this be found to be impracticable, that the mains be protected from mechanical injury to the satisfaction of the Council's chief engineer; and that drawings of the junction-box proposed to be placed in Cockspur-street shall be submitted for the approval of the Highways Committee before the box is constructed.

4. We have also to report the receipt of the undermentioned notices from the same company, given in accordance with the resolution of the Council to accept four days' (instead of one month's) notice in respect of the laying of service lines already laid:

21st April, 1891.—To 31, Savile-row, 33, Aldford-street, 35, Clarges-street, 8, Seamore-place, 67, New Bond-street, and 17 and 31, George-street.
22nd April, 1891.—To 12, Hanover-street, 18, Maddox-street, 2, 3, 8, 9, and 10, Great Pulteney-street, and The Blue Posts public-house, Rupert-street.
22nd April, 1891.—To the Royal Aquarium, Westminster.

5. We have likewise considered two notices from the Notting Hill Electric Lighting Company, dated April 17 and 20, 1891, respectively, of its intention to lay mains from No. 1, Airlie-gardens, crossing Campden-hill-road, and along Percy-villas to Hypatia Villa, and across High-street, Notting Hill Gate, south to No. 135 (one plan, 39A). The proposed works are unobjectionable; and we recommend—

> That the sanction of the Council be given to the works referred to in the notices dated April 17 and 20, 1891, respectively, of the Notting Hill Electric Lighting Company, upon condition that the company do give two days' notice to the Council's chief engineer before commencing the work; that the covering stones of the culvert shall be not less than 2in. thick; and that where the culvert crosses the carriageway, there shall be at least 9in. thickness of Portland cement concrete above the cover stones of the culvert in addition to the road material.

INSTITUTION OF ELECTRICAL ENGINEERS.

ADJOURNED DISCUSSION ON MR. ESSON'S PAPER, "NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS."

Authorised Abstract.

Mr. Mordey read a communication from **Mr. W. B. Sayers**. Mr. Esson, he pointed out, had made no mention of slotted armatures in his paper, although many of the results contained in it could, by simple modification, be applied to them. A mistake made by nearly all designers in considering this kind of machine was to assume that they required much less magnetising power than ordinary smooth-core machines. It was clear, however, that the ratios of the magnetising forces of the back and cross turns respectively on the armature to those on the magnet, must have limiting values irrespective of the air space, which values could not be exceeded without giving rise to great distortion of field and serious sparking. Short air-space machines had the disadvantage of a large induction in the armature at light loads, and the drop of volts with increase of current was serious. To make slotted-armature machines satisfactory they should have the same air space as those with smooth cores, that space being reckoned from the top of the iron projections. A slotted armature had therefore to be slightly larger than a smooth-cored one for a given output. The *sine qua non* of a good slotted-armature machine was that the sum of the areas of the teeth under a pole-piece was not less than the section of the core. The coils of these machines being nearly surrounded by iron had a greater self-induction, and therefore more lead was usually required to prevent sparking. The advantages of such armatures were that they combined positive driving and large clearance with considerable immunity from injury when removed for inspection or repair. To apply Mr. Esson's formulæ for the "volume of current" to slotted armatures, the air space should be reckoned from the tops of the projections. Obviously, the radial depth of the core must be measured from the bottom of the slots. Speaking of Prof. Thompson's remarks on the comparison of Fig. 4 considered as a two and a four pole machine, he said that if correctly reported, he (Prof. Thompson) had apparently overlooked the fact that for a two-pole machine the radial depth of the armature core would require to be doubled, and if used as shown, the E.M.F. as a two-pole machine would not be much increased, but the external current would be halved.

Mr. Esson, in his reply to Prof. Thompson's objections to the expression "volume of current," said it was for simplicity and to avoid the confusion which had arisen from using "ampere-turns," that he used the word "volume." The ampere-turns on any armature were $\frac{w\,C}{p^2}$, where w was the number of wires counted all round the outside, C the total current, and p the number of poles; and the fraction of this which produced the cross-field was $\frac{\phi\,p}{360}$. This gives $\frac{w\,C}{p}\ \frac{\phi}{360}$ as the cross-magnetising ampere-turns, and for simplicity he wrote it $\frac{v\,\phi}{360}$, where v represented $\frac{w\,C}{p}$. Respecting the comparison of a double-magnet two-pole machine with a four-pole one, he said that the best comparison all depended on the size of the machine. Even if it were so large that it was desirable to make it of the four-pole type, there was still the alternative that it might be made two-pole, if the double horseshoe were practically split where the like poles abutted together. It would, he said, be a mistake to compare a small two-pole machine with a four-pole one, since a single magnet, where it could be used, was better; and it was only when the air gap necessary to prevent sparking was greater than that needed for the copper that a multipolar machine was to be preferred. Speaking of the ratio of copper to iron in the machines shown in Figs. 1 and 2, he pointed out that this ratio might be anything depending on the efficiency of the machines. Mr. Kapp had contended that the four-pole Gramme field, Fig. 7, was lighter than the double horseshoe shown in Fig. 4, when the same materials were used; this, he thought, was a mistake, for owing to the greater length of yoke in the former, the weights were as 4 to 3 With reference to the relation between the temperature and peripheral velocity of armatures, he had no very precise data; but, from some preliminary experiments, he believed that connection was approximately represented by $C^\circ = \frac{W\,330}{\cdot 0005\,V\,S}$; where C^0 was the rise in degrees centigrade, W the watts expended, V the velocity in feet per minute, and S the surface in square centimetres. He agreed with Mr. Anderson that increasing the number of sections diminished sparking, but he had wished to emphasise the fact that if the load exceeded a given value, no non-sparking position could be found for the brushes; this was true whatever the number of sections. He had then pointed out that in no actual machine did the load exceed half the limiting value. As regards Mr. Swinburne's remarks, he said he had no desire to hint that because the formulæ were calculated they were wrong. On the contrary, the calculations were most valuable, but the equations could only indicate relations and not absolute values, and one had to go to practice to obtain data. He entirely agreed with Mr. Crompton about the economy of material effected by making multipolar machines, for his own experience showed the saving to approach very closely the 40 per cent. mentioned by Mr. Crompton.

DISCUSSION ON MAJOR P. CARDEW'S PAPER ON "A FEW CALCULATIONS ON ELECTRIC SHOCKS FROM CONTACT WITH HIGH-PRESSURE CONDUCTORS."

Dr. Fleming said the subject treated of was of great practical importance when dealing with pressures exceeding 100 volts. Considerable misapprehension existed on the subject, for it was commonly considered that high pressures were intrinsically dangerous. This, however, was not the case, for, as Mr. Latimer Clark showed years ago, a person could without injury receive a shock from hundreds of thousands of volts provided the quantity of electricity passed through the body was not large. To get a serious shock such as would cause physiological damage, it was evident that some appreciable current was necessary. The amount required to produce painful sensations differed greatly both with different subjects and with the portions of the body through which the current was passed. Some years ago he had tested himself, and found that four or five milliamperes passed through the head produced "swimming in the head," whereas from hand to hand he could tolerate 20 to 30 milliamperes. Some persons might, he thought, be able to take 20 milliamperes through the head. It was not at all unlikely that $\frac{1}{3}$ of an ampere, probably less, passed through any vital organ would prove fatal. Referring to the question as to how the body acts towards the current, whether like a condenser, voltmeter, or resistance, he said that the condenser effects were small, but undoubtedly it acted like a voltmeter or secondary battery, for it could be polarised, and a current subsequently obtained from it. Measurements of resistance depended greatly on the character and humidity of the skin. At Cambridge, where many experiments were made, it was found that the resistances of boating-men from hand to hand were unusually high, and to eliminate more or less the difficulty of obtaining good contact, Maxwell suggested that the hands be blistered and connection made by pushing needles through the skin. The experiments were not continued. On the subject of whether a person making a joint in active high-pressure mains, on an insulated chair, he said that if the body acts like a condenser, serious physiological damage might result from a contact under such circumstances, particularly if the current be alternating. The theory that some such condenser action existed was supported by the fact that moderate alternating or fluctuating pressures produced more painful sensations than equal continuous ones. If, however, physiological damage was the result of the electrolysis of some vital tissues, then direct currents would be more likely to prove fatal than alternating currents of the same strength. One interesting fact brought out in Major Cardew's paper—viz., that the outer conductor of a concentric cable is naturally at zero potential—he had verified experimentally. He considered it an important point in favour of concentric conductors for high-pressure distribution, and thought the fact ought to be more generally known. In conclusion, he said that quantitative information and data respecting electric shocks, accidental or otherwise, were greatly needed before the subject could be thoroughly investigated.

Mr. H. Newman Lawrence said he had made many experiments on the resistance of persons and on the currents required to produce discomfort, etc. He would not like to have passed the four or five milliamperes, mentioned by Dr. Fleming, through his own head, and thought it improbable that some persons might withstand 20 milliamperes through that part of the body. The direction of the current with respect to the brain was, however, of great importance. Transverse currents produced most effect, and he found it possible to withstand two or three times as much current when passed longitudinally. Although the pain experienced by the passage of such currents, the after results might be serious. In commenting on the difficulty in obtaining reliable information in cases of accidents or other serious shocks, he expressed a hope that the Institution might be able to collect such statistics as completely as possible. Generally, he said, the conditions as to area of contact, condition of skin, earth connections, etc., were not at all clear, and no idea could be gathered from ordinary information as to the actual current passed. He agreed with Dr. Fleming that it was the quantity passed through the body that was the important factor. He knew the pressure was not essential, and the ordinary statements that persons received shocks from a certain number of volts were generally misleading.

Mr. Addenbrooke remarked that in connection with the Grosvenor Gallery installation he had experienced shocks, and once made an overhead joint on a 2,500-volt circuit with the pressure on. To do this he had a strong teak bracket fixed to the post, and all the wood and metal work near was covered with indiarubber sheeting. Special tools with insulating handles were used, and a dry day chosen. When he touched the conductor faint blue sparks passed, but nothing to produce discomfort. On another occasion he unconsciously put his hand across a high-pressure switch, and, although he had no recollection of experiencing any shock, he was thrown down. Several men he knew had received serious shocks from a 2,500-volt circuit. In one case a man was putting up a transformer, and, clinging to an iron bracket that had been recently cemented into a wall with one hand, he reached up to one of the primary conductors with the other. The pressure was on, and the man was fixed in that position until he was pulled down by his comrade. His hands were severely burnt, and he received a severe shock to the system. In another case, when rearranging a customer's service lines, an arc started through a crack in the insulation to a man's hand, in which he was holding the wire. He was fixed to the post for some time before being released. The hand was badly burnt, and looked as if a red-hot poker had been laid on for some time. He (Mr. Addenbrooke) believed that the arc was started by perspiration from the man's hand penetrating the crack, and making connection through his body to the post. So far as he knew, this man's constitution was not permanently affected by the shock.

Mr. Mordey remarked that at the Brush Works they had made high-pressure electrical machinery for the last ten years, and although their testing arrangements were of a temporary kind, and much unskilled labour was employed, they had never had a serious accident due to electrical machinery. Only one instance had occurred in which a man was made insensible. This was a lamptrimmer, who, in taking down a lamp, completed the circuit of a No. 8 Brush machine through his body. A bright arc was seen to pass for some time between the lamp and his hand. He fell from the ladder, and had received a severe burn and shock, but although a large current must have passed, he suffered no permanent injury to the system. He himself once disconnected the circuit of a No. 7 machine, and held the wires, one in each hand, thus completing the circuit. At the time he was conscious of having an idea that the brushes of the machine needed shifting to reduce the great sparking that occurred, but he did not know what he had done until after he was released by stopping the machine. Referring to Dr. Fleming's remarks about making joints in high-pressure mains by means of insulated chairs, he said there was no difficulty whatever in doing so. The average person had not sufficient capacity to obtain a dangerous shock. At the Brush Works they constantly handled high-pressure wires with bare hands, and rarely found it necessary to take any precaution, unless the pressure exceeded 2,000 volts, then they merely stood on indiarubber mats. A packer once in their employ was particularly insensitive to fairly large pressures, for he commonly took hold of the terminals of machines giving about 800 volts. His experience with concentric cables confirmed the statements made by Major Cardew and Dr. Fleming—viz., that the outer conductor was at zero potential. In considering the shocks obtainable from a given source, he said the internal resistance of the source was of great importance, and as an instance adduced the fact that vacuum tubes, although requiring induction coils giving sparks corresponding to many thousands of volts to work them, were blown to pieces when put on a 1,000-volt alternator.

Mr. H. Human asked Dr. Fleming that as he considered danger more a question of current than of pressure, whether he would prefer to take hold of the primary terminals of a transformer rather than those of the secondary.

Prof. Ayrton pointed out that the fact of the outside of a concentric cable being at zero potential depended on the outside being near earth. It would not necessarily be so if it was far removed from other conductors.

Prof. Perry enquired whether the whole concentric system and generator, if insulated, might not be charged to, say, 1,000,000 volts above the earth potential.

Major Cardew, in reply to Prof. Perry, said this could only be done by means of an external source, and in his calculations he had postulated the absence of such sources. There was, he said, no doubt that considerable polarisation could be produced in the human body, for he found that its resistance to steady currents goes down as the pressure increases, and tends to a value which is approximately the same as that found by measurements with alternating currents. For small pressures, however, the effects produced by alternating or fluctuating pressures were much greater than with steady ones. He called Mr. Addenbrooke's attention to a fact pointed out in his paper—viz., that touching a conductor of a, say, 2,500-volt system did not necessarily imply that a shock corresponding to that pressure was experienced, for the act of contact, in reducing the resistance to earth, would probably lower the difference of potential to about one-third of the stated value.

PHYSICAL SOCIETY.—April 17.

Prof. W. E. AYRTON, F.R.S., President, in the chair.

The following communications were made:

"On a Property of Magnetic Shunts," by **Prof. S. P. Thompson, D.Sc.** After referring to a few instances in which magnetic shunts are employed, as, for example, the ordinary magnetic medical coil and Trotter's constant-current dynamo, he said that the particular property he wished to speak of was the time taken for such a shunt to lose its magnetism as compared with the other branch of the magnetic circuit. If these times were very different, unexpected results might be produced, and these might be regarded as being due to a kind of magnetic time-constants. Short pieces, as was well known, demagnetise much more rapidly than long ones, particularly if the latter form, or be part of, a closed magnetic circuit. Hence in alternators, such as Kingdon's keeper dynamo, in which both magnets and armature are stationary, it was important that the revolving keepers should be short. The most important application of a magnetic shunt occurred, he said, in d'Arlincourt's relay, described in Vol. IV., *Journal* of the Society of Telegraph Engineers and Electricians, and shown diagrammatically in Fig. 1. In this, relay the polarised tongue, T, plays between two projections *a* and *b*, near the yoke Y, and it is claimed to have a quicker action than ordinary kinds. The reason of this the author explained as follows: When a current flows through the coils, the greater part of the magnetic lines pass through the yoke, but a few leak across from *a* to *b* and move the tongue against the contact, P. On stopping the current, the magnetism in the extremities, A and B, dies away much more rapidly than in the yoke, consequently the direction of the field between *a* and *b* is reversed, and the tongue, T, thrown back against the stop, Q. **Prof. Perry** asked if any experiments had been made to test whether the throwing back actually occurred. He also enquired whether such action would be augmented, or otherwise, by having a thick copper tube round the yoke, or by laminating the iron. **Mr. Blakesley** asked if placing a yoke across A B would not improve the action. The **President** said he would be glad to know whether the relay was any more sensitive than an ordinary one as regards the ampere-turns, or the watts required to actuate the instrument. In India he remembered that they use inductive coils, shunting the ordinary relays, in order to expedite the action and to avoid confused signals arising from the electrostatic capacity of long lines. In reply, **Prof. Thompson** said he had tried one experiment on a horseshoe electromagnet, and found evidence of throwing back when working near the bend or yoke. Putting a yoke across A B would, he thought, tend to neutralise the effect desired.

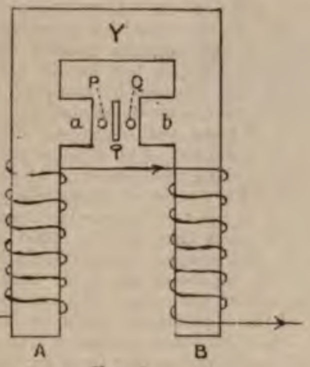


Fig. 1.

"**An Alternating-Current Influence Machine**," by **James Wimshurst**. This machine consists of a varnished glass disc, with or without metallic sectors, mounted on an axis, and rotating within a square wooden frame fixed in the plain of the disc. The frame carries four square glass plates, each of which has one corner cut away, so as to clear the boss of the disc. These plates are placed one at each corner of the frame, alternately on the two sides, and the disc revolves between them. There are thus two plates on one side of the disc situated at opposite ends of a diagonal of the frame, and two on the other side of the disc at opposite ends of the other diagonal. Tinfoil sectors fixed to the outer sides of the plates act as inductors, and wire brushes connected with them touch the disc about 90deg. behind the centre of the inductors. The peculiarity of the machine is that, although sparks can be readily obtained from it, a Leyden jar cannot be charged by bringing it to one of the terminals. From this the author concluded that the electricity produced was alternatively of positive and negative sign, and this he showed to be the case by means of an electroscope. The alternations, he said, occurred about every threequarters of a revolution, the suspended paper discs which he used as an electroscope remaining apart for that period, and collapsing during the next quarter of a turn. Using discs with various numbers and sizes of sectors, the author finds that the smaller the sectors and the fewer the number, the greater the quantity of electricity produced. Plain varnished glass is the best in this respect. Such a disc, however, does not excite itself quite so freely as one having numerous metallic sectors. By removing two of the inductors and placing an insulating rod carrying collecting brushes at its ends across a diameter of the disc, the machine was used to produce direct currents. Numerous discs and various shaped inductors accompanied the machine, by means of which a Holtz, Voss, or ordinary influence machine could be imitated. **Prof. S. P. Thompson** congratulated the author on the most interesting and puzzling machine he had brought before the society. He enquired if the machine would work if the direction of the rotation was reversed, or if two of the inductors were removed, and also whether all the four inductors are electrically of the same sign at the same instant. In reply **Mr. Wimshurst** said the machine would not excite if the direction of rotation be changed without also changing the direction of the brush arms, but it would work as a direct-current machine when two inductors were removed.

"**On Erecting Prisms for the Optical Lantern, and on a New Form of Erecting Prism made by Mr. Ahrens**," by **Prof. S. P. Thompson, D.Sc.** The ordinary form of erecting prism — viz., a right-angled isosceles one—was, the author pointed out, open to the objection that the top halves of the faces enclosing the right angle were nearly useless, for only the light which after the first refraction is totally reflected by the hypothenuse face can be utilised. The fraction of the side which is useful varies with the refractive index, being ·46 when $\mu = 1{\cdot}5$, and ·525 when $\mu = 1{\cdot}65$. To increase these proportions, prisms with angles of 105deg. and 126deg. have been used by Wright and others, and in some cases the prisms have been truncated. With such large angles, much light is lost by reflection. Bertin employed two truncated right-angled prisms placed base to base, with an air film between them. Nachet has also made erecting prisms for microscopes, in which internal reflections occurs from faces inclined at an angle of 81deg. to each other. This form of prism suggested to Mr. Ahrens the new form now shown, and which may be described as a long right-angled prism whose ends are cut off so to be parallel to each other and inclined at 45deg. to the hypothenuse face. The longitudinal *acute angles not being* required, are truncated. Light falling parallel to the axis at one end of the prism is refracted, and after internal reflections, emerges parallel but perverted. It is claimed that this form of prism gives, weight for weight, a larger angular field than any previously made. The performance of the new form of prism, and also of the ordinary forms, was tested before the society.

At the close of the meeting, Dr. Atkinson, who had previously taken the chair, announced that the next meeting would be held at Cambridge on May 9, instead of May 8, as previously intended.

LEGAL INTELLIGENCE.

THE KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY, LIMITED, v. THE LANE FOX ELECTRICAL COMPANY, LIMITED.

The Lane Fox Patents.

Before Mr. Justice Stirling in the Chancery Division of the High Court of Justice, on Friday, April 24.

This was a a motion by the plaintiff company asking for an injunction to restrain the defendant company from threatening the plaintiffs, their customers, or any other person or persons with legal proceedings or liability in respect of any alleged infringement of certain letters-patent claimed by the defendants to have been assigned to them. The letters-patent related to an invention of which Mr. St. George Lane Fox, an electrical engineer, was the author. He was the registered owner of the patent, but he had, by an agreement dated July 31, 1890, agreed to assign it to the defendant company, of which he was the managing director, and a large shareholder. On November 15, 1890, he had commenced an action against the plaintiff company to restrain them from infringing his patent, but the plaintiff company had not yet put in their defence. On February 21, 1891, the defendant company sent the following letter to Messrs. John Barker and Company, of Kensington: "We understand that your house is being supplied with electric light by the Kensington and Knightsbridge Electric Supply Company, which company, as you are doubtless aware, is now being sued for damages for infringement of our patented system of electric distribution. We have been advised that you, as one of the users of the said system, are liable for the infringement. We beg, therefore, to caution you of the fact, and to offer you an indemnity upon the terms contained in the enclosed circular. These terms, however, are to be considered as withdrawn if not accepted by the 28th inst." The circular referred to in this letter was to the effect that the Lane Fox Electrical Company, Limited, by whom all Mr. Lane Fox's patents for this system of electric light distribution were stated to be held, were prepared to grant licenses for the use of the system on certain terms therein set out. A similar communication had been sent by the defendant company to numerous other customers of the plaintiff company, and it was against this course of action that the present motion was directed. It was said on behalf of the defendant company that it had been decided that where an action had been commenced before the threats were made, an injunction to restrain the threats would not be granted, and here such an action had been brought. It was necessary to bring the action in Mr. Lane Fox's name, the patent being vested in him, but the defendants were the real owners in equity. The question turned upon the construction of section 32 of the Patents, etc., Act, 1883, which provides that: "Where any person, claiming to be the patentee of an invention, by circulars, advertisement, or otherwise, threatens any other person with any legal proceedings or liability in respect of any alleged manufacture, use, sale, or purchase of the invention, any person or persons aggrieved thereby may bring an action against him, and may obtain an injunction against the continuance of such threats, and may recover such damage (if any) as may have been sustained thereby, if the alleged manufacturer use, sale, or purchase to which the threats related was not in fact an infringement of any legal rights of the person making such threats. Provided that this section shall not apply if the person making such threats with due diligence commences and prosecutes an action for infringement of his patent."

Mr. Graham Hastings, Q.C., and Mr. Wallace were for the plaintiff company, and Mr. J. C. Graham for the defendants.

Mr. Justice Stirling said that no doubt the letter complained of contained a threat. The defendant company claimed by the circular to have acquired the rights of the patentee of the invention, and were therefore within the definition of the Act. By the Act any person aggrieved might bring an action against anyone uttering threats. The plaintiff company were undoubtedly persons aggrieved, and might bring an action against any person whose "legal rights" were alleged to be infringed. But here the defendant company had no legal rights, for Mr. Lane Fox had only agreed to assign his rights to them. Therefore the defendant company, the persons making the threats, were simply entitled in equity to an assignment of the patent upon certain terms not disclosed. That the defendant company were not entitled to sue was clearly shown by the fact that Mr. Lane Fox had brought an action in his own name. The constitution of the company was somewhat remarkable. The capital consisted of 100 £1 shares, which were deemed to have been fully paid up, and Mr. Lane Fox might have good reason for not wishing to clothe them with the legal title so as to enable them to sue in respect of an infringement. There was only an equity here, to enforce which the company would have to bring an action against

Mr. Lane Fox. Then did the proviso apply? The action was not brought by the persons making the threats, but by the legal owner of the patent, Mr. Lane Fox, and damages for the threats could only be recovered from this company with a nominal capital of £100. Consequently an order must be made for an injunction to restrain the continuance of such threats.

CLARK AND OTHERS v. THE WESTMINSTER ELECTRIC SUPPLY CORPORATION, LIMITED.

This action came before Mr. Justice Hawkins and a special jury in the Queen's Bench Division of the High Court of Justice early in this week.

The plaintiffs, who are the well-known firm of electrical engineers, carrying on business at the Regency Works, Westminster, sued the defendants to enforce the specific performance of a certain alleged agreement dated December 5, 1889, between them and the defendants, or, in the alternative, for damages for an alleged breach of that contract. The defendants have obtained powers to supply electricity as an illuminating power within certain areas in the city of Westminster under a provisional order, confirmed by Act of Parliament (52 and 53 Vict., cap. 178). The plaintiffs alleged that they, as electrical engineers, had rendered the defendants services in obtaining these powers, and that subsequently, on December 5, 1889, by an instrument of that date, the defendants had entered into an agreement with the plaintiff company to employ them to do and perform certain works and services therein mentioned to an amount of not less than £100,000 upon the terms and conditions therein specified, and they also agreed that they would, before the commencement of the works, enter into a formal and detailed contract containing all usual conditions for carrying out such agreement of December 5, 1889, to be settled by the parties thereto, or, in case of difference, then by Mr. F. Moulton, Q.C. It was further alleged that the defendants, in order to obtain capital from the public to enable them to carry out the business and secure the advantages given them by Parliament, had issued a prospectus stating, as the fact was alleged to be, that the plaintiffs had entered into the said agreement with them—and so inducing the public to believe that the capital supplied would be expended in work which, to the extent of £100,000, would be carried out by the plaintiff company, whose repute as electrical engineers is high and well known—the defendants obtained such capital; and that the defendants not only have refused and do refuse to perform their said agreement of December 5, 1889, but threaten and intend to give the said works and services to be done and performed by other contractors. The plaintiffs estimated their loss because of the defendants' alleged conduct at £15,000. The defendants denied that they ever made the agreement alleged. They pleaded that the said agreement was delivered by the defendants to Messrs. Fowler and Co., their solicitors, as an escrow only, upon the terms that it should not take effect or be operative or enforceable until the fulfilment of the following condition—viz., that the plaintiffs should forthwith subscribe for 3,333 shares of £5 each in the defendant company. The plaintiffs, the defendants alleged, had never so subscribed. Save as aforesaid, the defendants denied each and every of the allegations in the statement of claim. Upon the defence, the plaintiffs joined issue.

Sir Charles Russell, Q.C., and Mr. Pollard appeared for the plaintiffs; and the Attorney-General (Sir R. Webster, Q.C.), Mr. F. S. Moulton, Q.C., and Mr. A. B. Shaw were for the defendant company.

Mr. Pollard having opened the pleadings,

Sir Charles Russell, Q.C., opened the case, which, from the voluminous evidence affecting it, was of a very detailed and somewhat complicated nature, at considerable length, and, in conclusion, he submitted that the action was practically undefended.

Mr. Murdock, who was then called, said that he was the secretary of the plaintiff company, which had been established some time, in November and December, 1889. He saw the agreement of December 5, 1889, sealed by his company, and then took it on to Mr. Fowler, the defendants' solicitor. He asked him to exchange documents. He said he could not do so, as it had been arranged with Mr. Latimer Clark that he (Fowler) should hold both parts as trustee for both parties until after the allotment of shares of the defendants' proposed company. Witness then said that if he would give him a letter to that effect he would leave the plaintiffs' part of the contract with him. Mr. Fowler did so, in which he stated the fact, and which was dated incorrectly as December 6. Mr. Fowler mentioned no other condition.

Cross-examined by the **Attorney-General**, in his company its shares were largely held by Messrs. Latimer Clark and Muirhead. It had been a private firm. The board ordered him to go and see Mr. Fowler; Mr. L. Clark was the chairman, and he gave them to him. At the defendants' board meetings, held on December 2nd and December 5th, he did not know who had been present.

Mr. John Muirhead, called, said he was a director of the plaintiff company since it was incorporated six or seven years ago. Prior to that for many years they had carried on the same business at Westminster as a private firm. Their capital was £50,000 ordinary shares. His personal interest in it was about £15,000. The nominal capital was £100,000 in £10 shares. They had carried out the St. James's and Pall-mall electrical installation prior to the subject-matter in this section. This fact was well known. They first saw Mr. Brown Martin and Mr. Wallace—the two active directors in the defendant company—in March 1889, about these matters.

Asked, amongst other things, Did you not agree to provide expert evidence before the committee when applying for a provisional order?

The **Attorney-General**: I object to that question. We have written offering to pay the plaintiffs for all they did in that respect, and they are now suing, not for that at all, but for the breach of this particular contract.

Mr. Justice Hawkins: That is so.

Examination continued: He was present and heard Mr. Brown Martin give evidence in answer to cross-examination.

Sir R. Webster: That is not evidence here; anything said before the committee cannot affect this issue at all.

Mr. Pollard: The defence shows there is to be a conflict of testimony. It is, I submit, admissible.

Mr. Justice Hawkins: The issue here seems to me to be a very simple one—viz., ay or no. Are the terms upon which this agreement was given to Mr. Fowler as asserted by the plaintiffs or as by the defendants? And in that view I do not see quite how, at present, such evidence as you propose can be relative.

Examination continued: Prior to December 5, 1889, there was no condition that this agreement should only be operative if his company subscribed for a certain proportion of shares.

Cross-examined: Mr. Frank Muirhead, his brother, was also a director in the plaintiff company. He was at defendants' offices on December 2, 1889, in company with Mr. Latimer Clark. He there saw the whole of the defendant board. Lord Suffield in the chair, Sir D. Gordon, Mr. Wallace, Mr. Brown Martin he knew, but the other two mentioned he did not know by sight. He did not see Mr. Crompton there at the same time as himself, but he had noticed that gentleman leaving the board-room as he (witness) entered it. At that meeting the only conversation about financing the proposed company was with Mr. Latimer Clark, but he remembered no suggestion that his company should subscribe towards the capital. Mr. Frank Muirhead had never told him that their company must subscribe £25,000 towards the proposed company. He could not remember ever mentioning anything as to a minimum subscription in the contract. He could not remember that on December 5, at the company's offices, Mr. Wallace had told him that he would have the contract sealed by his company as soon as witness agreed to subscribe the £16,000, or that he had said until he did so it would be left inoperative in Mr. Fowler's hands. He was surprised when he heard of the agreements being held by Mr. Fowler as a trustee.

Mr. Frank Muirhead, Mr. Latimer Clark, and other witnesses having been called for the plaintiffs, their case was closed, and the next day, upon resuming,

The **Attorney-General** (Sir R. Webster) had commenced to open the defence, when

Mr. Justice Hawkins said: Is this not a case where the parties might in some way meet each other? I can see difficulties in it which make me fear that, in any event, it will not end here.

The **Attorney-General**: I quite appreciate what your Lordship says.

Mr. Justice Hawkins: It makes no difference to me what the parties do, but it does occur to me, after hearing the plaintiffs' evidence, that there have been errors on both sides.

The **Attorney-General**, after some time had elapsed in negotiation between the parties, said he was glad to be able to tell his lordship that they had acted upon his suggestion and come to terms. The defendants were willing to give the plaintiffs a sum of £4,000—to include everything—and it was agreed that all recriminations on both sides should be unreservedly withdrawn, and that the plaintiffs' tenders for work should be treated fairly with all other tenders. The defendants could not, as directors, promise more than that, as it would be a fraud on their shareholders to give preference to any contractor over another, or others.

Sir Charles Russell, in accepting these terms on behalf of the plaintiffs, said that his clients were most anxious to let bygones be bygones between them and the defendants, and had chiefly been influenced in agreeing to this settlement by a desire to re-establish that friendly relationship which had always existed between them prior to this dispute. Everyone who had heard the plaintiffs' evidence must have marked the full and frank manner in which it had been given, even in some instances so frankly as to have told somewhat against their case. He did sincerely hope that this settlement would be final, and that the parties might once more be friends and continue to work together in each other's interests.

Mr. Justice Hawkins, in expressing approval, said that he was very glad that this course had been adopted. It was most creditable to all parties. He had suggested the settlement because, from what he saw of the case during the plaintiffs' evidence, he sincerely thought it in the real interests of both parties; and he truly hoped that it would be the means of once more establishing a friendly relationship between the plaintiffs and the defendants. There would, therefore, be judgment by consent for the plaintiffs for £4,000, and a certificate for a special jury.—*Times.*

COMPANIES' MEETINGS.

METROPOLITAN ELECTRIC SUPPLY COMPANY.

The fourth ordinary general meeting of this Company was held at Winchester House on Wednesday, Sir John Pender, K.C.M.G., the chairman, presiding.

The report and accounts having been taken as read,

The **Chairman** said: As this is an important meeting, and one at which it is desirable that the shareholders should clearly understand the position of the Company and how the finances have been dealt with during the last 15 months, I propose to put before you a statement which will be valuable in the future as a record of the past. The form in which the accounts are presented is new, but in accordance with the requirements of the Board of Trade, who, under the provisions of the Electric Lighting Act, have power to prescribe in what manner the accounts of all electric light undertakings are to be furnished to them for public information. The balance-sheet which accompanied the report to September 30, 1889, dealt with a period which ended only a few weeks after the granting of the orders under which we were then working, and covered the expenditure attendant upon the starting of the Company's operations, and the commencement of its working, which at that time only included a few customers. Although it was known that the Board of Trade possessed the powers to which I have referred, the Company were at that time without information as to what would be required. Acting under the advice of the Company's auditors, the accounts were prepared and laid before you in the ordinary form of a company's balance-sheet. Since then, however, the Board of Trade have prescribed a form of account, which, although not yet finally settled, being still under discussion in some minor particulars, is sufficiently comprehensive for the purpose required, and has been followed as closely as possible in the accounts now before you. I may say that we were given to understand by the Board that they would be content with a detailed account for the period commencing with the date of the last balance-sheet, dealing with the expenditure prior to that date as a lump sum, but on carefully going into the matter we found that such a mode of dealing with the figures could not be a satisfactory one, and the whole of the accounts from the commencement of the Company have, therefore, been reconstructed in order that the present and future balance-sheets might give a clear record of what the Company has done and is doing. The accounts speak for themselves, and you will from them be able to form a fair idea of the amount of work which has had to be carried out, and the time and care, as well as money, which has had to be expended, to bring the Company's various undertakings to their present condition of practically complete working. There is one item of detail to which I ought to refer; I allude to the apportionment of management and general expenditure between capital and revenue. During the 15 months over which the accounts extend, the direct capital expenditure amounted to £195,000, while the total turnover revenue which has been handled was only £27,000, from which it will be evident that the time and attention of the Board and staff, with the exception of the actual station staff, which, of course, is wholly paid for out of revenue, has been mainly occupied with capital details. In view of this fact, the Board have considered that the proportion of management and general expenditure shown in the accounts as chargeable to revenue is a liberal one, and it is satisfactory to find that with this charge, the revenue, which has been mainly earned during the latter portion of the period, shows a profit, though, of course, only small. The Board are fully alive to the fact that as capital expenditure decreases the proportion of charge to revenue must very largely increase, until in a little while the whole load of management has to be borne by revenue; but, making all allowances for this increase of charge, the revenue is now growing so satisfactorily that future success is assured. With regard to the interim dividend of 2s. per share for the three months ending March 31 last, I am glad to be able to tell you that the income for that period shows an actual increase on that for the December quarter, although we have, of course, had to deal with brighter weather and individually smaller requirements than in October, November, and December. Our expenditure has not proportionately increased, and, making a full allowance for management expenses, we have no hesitation in saying that the profits for the quarter amply justify the interim distribution which we have had the pleasure to announce, and which is a tangible proof that the anticipations which we have held out at previous meetings are in a fair way of being fulfilled. The remarks which I made when I last had the pleasure of meeting you in November will, I think, be sufficiently fresh in your minds to obviate the necessity of my dealing at any great length with the period which the report embraces. It may, however, be interesting for you to realise the difference of our position at the commencement and the close of this period, and for this purpose I would remind you that in October, 1889, we had just opened the first portion of our Sardinia-street station, and had run temporarily a few overhead lines to connect up our first customers. Our Rathbone-place station was also supplying a few customers by means of overhead wires and the small plant which we had then lately purchased with the building from Messrs. Pritchett. The erection of the Manchester-square station had not even been commenced. Our Whitehall station was then, as it is now, doing good and steady work. The total number of lamp connections was, on October 1, 1889, 6,111; it is to-day 60,000. Our customers then numbered 37, and now amount to 480; and as our report informs you, our revenue, which for the quarter ending December 31, 1889, was £2,366. 15s. 7d., amounted for the corresponding period of 1890 to £10,726. 19s., an increase of 275 per cent. During this period the plant at Sardinia-street has been duplicated; the new plant at Rathbone-place has been installed; the Manchester-square station has been erected and fully equipped, and an elaborate network of underground mains, about which I will speak to you later on, has been laid down. With the growth of our capabilities of supply has also grown our business; and with the growth of our business we are pleased to say that the demand for the light also appears steadily to grow, so that I fully believe that at our next year's meeting we shall be able to report to you a lamp connection of—well, I may say, 100,000 lights, if not more. And you must remember that this, and an even greater increase in our business can be amply dealt with by our existing machinery, and, as I endeavoured to explain to you at our last meeting, the greater our production the less in proportion will be our expense of production. Therefore, if we can show a profit when supplying 50,000 lights, we can proportionately show a much larger profit when supplying 100,000 lights. I have had a diagram prepared for you which will show you at a glance the present position of our business. On this diagram each black mark represents a consumer's house, and you will at once realise that we are still only on the threshold of our work, and that even when our present output is doubled, much—very much—remains to be done. Looked at from this point of view, a map of London forcibly reminds me of a map of Africa, and we, like my friend Mr. Stanley and so many others, are engaged in filling up the blank spaces, and in illuminating the darkness which is still but too apparent. Our work is still essentially a pioneering one, and if we can make a pioneering business pay it augurs well for our profits hereafter. And here I would like to make a few remarks as to the choice we have made of the system for supplying electricity to the public. The system we have mainly adopted is that known as the alternate-current transformer, which we work at the extremely moderate pressure of 1,000 volts. We elected to adopt it under the very best practical and scientific advice, as being the system best fitted for pioneering work. We have every reason to be satisfied with our choice, for it has enabled us to cover our large areas at infinitely less cost than any other known system would have done. The advocates of other systems have been lately doing their best to disparage the merits of the alternating current, and have endeavoured to make a strong point out of the loss of energy which, to a certain extent, undoubtedly occurs in connection with the transforming apparatus; but allow me to remind them that this loss is insignificant when compared to the heavy initial outlay which the use of the continuous current necessitates. And I would, moreover, point out that any loss which we have to bear will be reduced to a minimum so soon as the increasing density of our lighting warrants the establishment of transformer sub-stations. This question of transformer sub-stations—or, as the Americans say, of banking transformers—has for a long while been receiving our careful attention, and we have all along had in view their ultimate adoption as soon as our business is sufficiently developed to ensure their being worked economically. Another great advantage of our system over all others adopted in London is that each of our alternate-current stations can assist or be assisted by any other; indeed, it is our usual practice at present to shut down one of our stations entirely during the hours when the load is lightest, and during the summer it is quite possible that we should find one station adequate to deal with the requirements of the whole of our areas during the hours of minimum demand, thus gaining considerable economy in working. In speaking to you of systems of supply, I daresay you all have in your minds that adopted by another great London supply company. We must all admire the indomitable pluck with which the difficulties inseparable from the achievement of such a scheme have been faced. We must all admit the genius of the engineer who is responsible for such a gigantic design, and most heartily do I wish him success; and we must acknowledge the accustomed skill displayed by my friend, the chairman of that company, in his recent review of their position and prospects. We sincerely trust that not only for their own sake, but for the sake of the cause of electric lighting generally, their success is now assured, and we are glad to think that we were able to be of some assistance to them in their hour of need. But as the chairman could not avoid attempting to make a point at our expense, in dealing with their anticipated immunity from vibration difficulties, so I venture to repeat the friendly warnings which I have often uttered before, namely, that it is dangerous to put all your eggs in one basket. One of the principal arguments brought by the London Corporation in establishing one large central station outside London was based on the fact that the Gas Light and Coke Company had done the same at Beckton, and what the gas company did after 50 years and more working on a more modest scale, our friends had done after three or four years of purely pioneering work. Of the two examples we prefer to follow that of the former, and to walk before we run. When our figures can show something like the returns of the Gas Light and Coke Company, with its 200,000 customers and its 1,000,000 tons of coal, which is, I believe, yearly required to meet the demands upon them, then will be the time for us to consider whether economy and efficiency will best be served by the erection of a great outlying generating station, or whether our present policy of smaller plants which can render one another mutual assistance, thus reducing the risk of failure of supply to a minimum, will even then be the soundest one. With regard to this vibration question, to which Mr. Forbes refers, it is, of course, inevitable that the erection of large machinery works in the midst of a great town like this should give rise to complaints. We have, of course, had to deal with grievances respecting ancient lights, alleged noise, and what not, about which I would say more but for the fact that we have at present two cases *sub judice*. I may, however, say this: that every precaution has been taken to prevent the possibility of any noise or vibration occurring; and, as a practical proof that such precautions can be taken with success, I would inform you that you are now sitting within a very few yards of a powerful plant which is working at this very moment, and which supplies the electricity and other requirements for the whole of this vast building. There is one other point in Mr. Forbes's remarks to which I would like to allude. In answer to a question respecting the amount receivable per lamp per annum, he is reported to have replied that £1 per light is not enough, and that his corporation would now refuse to take a contract at such a rate. If this applies to their customers as a whole, I must congratulate the London Corporation on their experience, which is quite at variance with that of ourselves or, I believe I may safely add, of any other London supply company. We can fully admit that there are classes of customers with whom a contract on such terms would be out of the question, whose consumption would need a far larger contract price than 20s. But against these classes have to be set what we may style the private customers, whose demands on our supply are comparatively small, and from whom it would be impossible, and, indeed, unfair, to obtain so high a price per light. I am speaking now of our experience as gained by our supply of current by meter, for I may inform you that the larger proportion of our customers are now charged by this means. Our experience of the average revenue obtained for each 8-c.p. lamp connection per annum places it at about 12s., and I believe that even this figure is a better one than is obtainable by companies whose area of supply is of a more purely residential character than ours. In making these remarks I do not wish you to think that we are losers by this experience. If you will reflect a moment, you will readily understand that the less each lamp in our system is used the greater may be the number of lamp connections our plant can safely deal with. We are, therefore, in a position to supply a far larger number of lights than we originally believed our plant was capable of meeting, and hence our operations are considerably widened, and we shall gain by number what we have lost by rate. Our stations have, as is stated in the report, worked very satisfactorily, and this is the more gratifying as they commenced to supply current before all the fittings and accessories were completed. With regard to our system of underground mains, I may state that the length of conduits at present laid amounts to 40 miles. The whole of this work has been executed under the immediate supervision of our own staff and by our own workmen—a more efficient and economical plan than that of employing a contractor. Into these conduits we have drawn 90 miles of mains, and it is matter of deep satisfaction for me to inform you that not one single fault or leakage has yet occurred in any one of our circuits. Anyone who realises what this means will readily agree as to the excellence of the cable employed, and to the skill and care with which our staff has manipulated it. It also tends to strengthen our conviction that the system we have adopted for our mains is the proper one. I must not omit to testify to the Board's appreciation of the loyalty and energy which has been displayed by our engineering staff, and to the skill with which they have overcome the many difficulties which have of necessity arisen in working new plants under trying conditions. I should also like to remind you that we have always made it a practice to give a constant supply by night and by day, and although, at any rate at first, and during the small hours of the night, the demand has scarcely justified us in doing this from an economical point of view, have, nevertheless, always believed it to be our first duty to honourably carry out the responsibilities which have been imposed upon us by our parliamentary obligations, and to prove to our customers that electric lighting is, no less than gas, reliable whenever wanted. With regard to our Paddington concession, which, you will remember, was granted to us last August, we are already making great progress in this district with our mains, and are already supplying upwards of 2,000 lights from our Manchester-square station. Indeed, had it not been for the exceptionally severe winter, which stopped our works for at least two months, our progress would have been still more marked. The large demand for light in this important parish renders it necessary for us to proceed at once with the erection of a station on the wharfside premises which we have acquired, and as the bulk of the machinery is already completed, and the building works to be commenced in a few days' time, we have every reason to believe that the station will be completed in time for next winter's lighting. You will observe from the report that, as far as we can at present estimate, the erection of this station with the supply mains and the completion of the present system of mains in our other districts, will as nearly as possible absorb our present issue of capital. We shall, therefore, soon issue notices for the payment of the final call of £1 per share, and I think that we shall be meeting the wishes of the shareholders in this respect, as there will then be no further liability on the shares, which will, therefore, improve their already favourable position on the market, and will tend to add to their attractiveness as a sound investment.

The Chairman then referred to some letters which they had received from customers testifying to the excellence of the supply, and concluded by stating that the Board had fulfilled to the letter the prospectus they put out, namely, that they were not going into a speculative system, but one which had proved successful in America. He believed every shilling of their money had been well spent, and they had established what he believed would be sound investment in the future. Before he met them again he believed they would have 100,000 lights, probably considerably more; and then, when they got a respectable dividend, and it was found that the way was clear, they (the Board) would not be backward in meeting any demand for extensions, and did not think they would have any difficulty in getting the money. After a complimentary reference to the Board of Trade and their officials, and to the retiring director, Mr. J. E. H. Gordon, who did not seek re-election, but remained as consulting engineer,

The Chairman moved the adoption of the report and accounts, which was seconded by **Sir G. Elliott, Bart., M.P.**, and carried unanimously.

Sir J. N. Fowler and Mr. J. C. Parkinson were re-elected directors, and Messrs. Deloitte, Dever, Griffiths, and Co., auditors.

REUTER'S TELEGRAM COMPANY.

The twenty-seventh ordinary general meeting of this Company was held at the office on Wednesday, Admiral Sir J. D. Hay, Bart, K.C.B., in the chair.

In moving the adoption of the report and accounts, the **Chairman** said that, roughly speaking, their telegraphic outlay had been £5,000 in excess of 1889, which was alone sufficient to account for the slightly diminished dividend. In these times 5 per cent. might be considered a fair return for capital invested, and as they carried forward nearly £1,000, he trusted that the shareholders would feel that they had reason to be satisfied.

Baron de Reuter seconded the motion.

The report was unanimously approved, and the dividend declared.

INDO-EUROPEAN TELEGRAPH COMPANY.

The twenty-fourth ordinary general meeting of this Company was held on Tuesday at Winchester House, **Mr. J. H. Tritton** presiding. He said that the receipts of the Company showed an increase of £5,518 over those of 1889, the gross receipts for the year 1890 being £113,807. The gross expenses were £57,901, being a decrease of £1,338 on those of the previous 12 months. As regarded maintenance expenses, there was an increased payment of about £2,000, owing to the appreciation of the rouble. There was also a loss on commercial account of £428 arising from the same cause. Notwithstanding this, the outcome compared favourably with that of last year. They placed £10,000 to the reserve, recommended the payment of a dividend which made up 10 per cent. for the year, and carried forward £4,168, as against £2,035 for 1889. The report was adopted, and the above dividend declared unanimously.

ELMORE'S FOREIGN AND COLONIAL COMPANY.

At an extraordinary general meeting of this Company held at the offices on Monday, **Mr. F. L. Rawson** presiding, the resolutions altering the articles of association, and passed at the extraordinary meeting held on the 6th ult., were confirmed.

COMPANIES' REPORTS.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY.

The report of the Directors for the year ending 1890, says the whole of the compulsory area has had its streets, with the exception of about three-quarters of a mile, supplied with mains, and in two and a half miles of streets external to this area mains have also been provided, making the total length of streets down which mains have been placed 10 miles, about four miles of which have been executed in the year 1890. It is computed that there are about 1,300 houses fronting on these mains, and on December 31 last only 291 were taking current. During the year the number of houses and shops connected with the system has increased from 147 on December 31, 1889, to 291 on December 31, 1890; while the number of lamps, calculated on the usual basis of 8 c.p., has increased from 11,794 to 25,535. The dividend on the 6 per cent. preference shares was duly paid to June 30, 1890, and out of the balance standing to the credit of the net revenue account on December 31, 1890—£1,804. 2s. 2d.—the sum of £922. 18s. 3d. has been appropriated for the payment of the preference dividend to that date, leaving £881. 3s. 11d. available for the next account.

SUBMARINE CABLES TRUST.

The report of the trustees for the financial year to April 15 shows that the revenue for this period, including £431 brought from the previous accounts, amounted to £24,098. The coupons due on April 15, 1890, were paid on October 15, 1890, and the coupons due on October 15, 1890, were paid on April 15, 1891. The expenses of the trust amounted to £1,175, and the payments on account of the coupons to £20,286—together £21,461—leaving a balance of £2,636 to be carried forward This balance, which is equivalent to 15s. 7d. per cent. on the value of the outstanding certificates, the trustees propose to distribute to the certificate holders on the 15th May, together with a small amount to be taken from the current year's revenue, so as to admit of the payment of £1 on account of the coupon due on the 15th April.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.

The report of the Directors for the half-year ended December 31, 1890, shows that the revenue amounted to £143,363, and the expenses to £18,106. After providing £12,880 for debenture interest and sinking funds, and £1,960 for income tax, there remains £110,416; to this is added £2,417 brought forward, making £112,833. First and second interim dividends amounting to £39,000 have been paid, and £50,000 transferred to the reserve fund, leaving £23,833 to be carried to the next account. Of this amount the Directors intend distributing £13,000, or 2s. per share, in addition to the usual quarterly dividend of 3s. per share, payable on June 24 next. The receipts for the half-year include £1,500 dividend to June 30, 1890, on the Company's shares in the African Direct Telegraph Company.

NEW COMPANIES REGISTERED.

British Electrolytic Syndicate, Limited.—Registered by Alfred Wells, 27, Chancery-lane, W.C., with a capital of £100,000 in £1 shares. To carry into effect an agreement expressed to be made between Frederick Bennett of the one part, and the company of the other part, and to carry on generally the business of miners, metallurgists, and smelters. The first subscribers are :

	Shares.
F. Safford, 2, Garden-court, Temple, E.C.	1
T. Lewis, Bryn Ogwen, Bangor	1
W. J. Tippetts, 11, Maiden-lane, Queen-street, E.C.	1
A. McLaren, 42, Newsome-street, Cootham, Redcar	1
H. T. Middleton, 8, Princes-street, Westminster, S.W.	1
A. C. Hutchins, Drayton Lodge, Ealing Dean, W.	1
A. J. Jordan, Keymer Vale, Keymer, Sussex	1

There shall not be less than three nor more than seven Directors ; the first shall be appointed by the subscribers to the memorandum of association. Qualification, £100. Remuneration, £1,000, with a further 5 per cent. after 15 per cent. dividend.

London Electrical Tramways Company, Limited.—Registered by Hurrell and Mayo, 165, Queen Victoria-street, E.C., with a capital of £150,000 in £1 shares. Object: to acquire the tramway system of the North London Tramways Company, and to carry on and develop and extend the same. The first subscribers are :

	Shares.
C. J. Westwood, 3, Adelaide-place, E.C.	1
F. C. Winby, 3, Adelaide-place, E.C.	1
C. Docwra, 3, Adelaide-place, E.C.	1
B. Laucler, Chigwell, Essex	1
E. J. Relf, 12, Humber-terrace, Westcombe-park, S.E.	1
R. Krugh, Hermon-hill, Wanstead	1
A. W. Hurrell, 165, Queen Victoria-street, E.C.	1

There shall not be less than three nor more than seven Directors : the first are the signatories to the memorandum of association. Qualification, £100. Remuneration to be determined in general meeting.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for last week were £5,998.

City and South London Railway.—The receipts for the week ending April 25th were £784, as compared with £816 for the week ending April 18th.

Western and Brazilian Telegraph Company.—The receipts for last week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £4,726.

Swan United Company.—The Directors of this Company have resolved to pay an interim dividend at the rate of 6 per cent. per annum for the half-year ending 31st March, 1891, to be distributed in accordance with the articles of association. The dividend will be paid upon the register as it stands this day, and the dividend warrants will be issued on 21st May next.

Dividend.—The Directors of the Western and Brazilian Telegraph Company have decided, after placing £20,000 to the reserve fund and £5,936 to the debenture redemption fund, to recommend at the forthcoming meeting a dividend of 9s. per share, free of income tax, making, with the interim distribution, £5 per cent. for the year 1890. The sum left to be carried forward is £6,070.

PROVISIONAL PATENTS, 1891.

APRIL 20.

6767. **Improved means for the production of ozone electrically.** William Lucas and Thomas Alexander Garrett, 128, Clerkenwell-road, London.

6773. **Improvements in apparatus for signalling time, and for regulating clocks by electricity.** Ludwig Von Orth, 46, Lincoln's-inn-fields, London.

6774. **Improvements relating to electric conductors.** Herbert de Reuter and Erasmo Enrico Maurizio Gower, 45, Southampton-buildings, London.

6782. **Improvements in dynamo-electric machines and electric motors.** Hugh Longbourne Callendar, 2, Princes-mansions, Victoria-street, London.

6793. **The application of electricity for the production of pyrotechnic and other similar effects, and apparatus therefor.** Pierre Charles Eugène Champion, 53, Chancery-lane, London.

APRIL 21.

6831. **Improvements in dynamo-electric machines.** Albert Lyman Parcelle, 55, Chancery-lane, London. (Complete specification.)

6846. **Improvements in printing telegraphs.** Samuel Rush Linville, 323, High Holborn, London. (Complete specification.)

6847. **Improvements in printing telegraphs.** Samuel Rush Linville and Louis Frederick Hettmansperger, 323, High Holborn, London. (Complete specification.)

6870. **Improvements in electric motors.** James William Thomas Cadett, 33, Southampton-buildings, London.

6881. **An improved method of and apparatus for covering electric wires.** Jabez Ellis Walcott, 45, Southampton-buildings, London. (Complete specification.)

6890. **Improvements in and connected with electric locks.** Frank Boulton Aspinall, 6, Breams-buildings, London.

6906. **Improvements in arc electric lamps.** George Wilkinson, 11, Furnival-street, London.

APRIL 22.

6908. **An electromagnetic gas controller.** James M'Laren, Public Library, Edinburgh.

6954. **Improvements in electrical switches.** William Samuel Sargeant, 35, Southampton-buildings, London.

6978. **Improvements in or relating to the automatic regulation of dynamo-electric machines.** Alfred Julius Boult, 323, High Holborn, London. (William Stone, Australia.)

APRIL 23.

7009. **Improvements in electric bells.** William Richard Wynne, 92, Quayside, Newcastle-on-Tyne.

7010. **Improvements in electrical mining keys, etc.** William Richard Wynne, 92, Quayside, Newcastle-on-Tyne.

7052. **Improved methods of obtaining electricity.** William Boggett, 34, Southampton-buildings, London.

7053. **Improvements appertaining to braces and sock and stocking suspenders or other articles of wearing apparel, and in the combination therewith of voltaic electric appliances; part of which invention is also applicable to specially-constructed articles or apparatus employed for particular medical treatment.** William Robert Faulkes, 34, Southampton-buildings, London.

APRIL 24.

7075. **Improvements in incandescent electric lamp holders, ceiling roses, and other like fittings.** F. H. Royce, Cooke-street, Hulme, Manchester.

7080. **Improvements in or connected with the manufacture of wall or other coverings, artificial leather, electrical insulators, boxes, and other articles from vegetable parchment.** Amedeé Wilbaux, 33, Chancery-lane, London.

7095. **Improvements in portable electric lamps.** Theophilus Coad, 1, Quality-court, London.

APRIL 25.

7126. **Improvements in electric lamp suspension fittings.** Hans Jensen, Jens Jensen, and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

7127. **Improvements in apparatus for indicating the proper working of electrical bells, annunciators, and the like.** Hans Jensen, Jens Jensen, and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

7160. **An improved method of producing a hermetical seal for the connecting wires of the filaments of incandescent lamps.** Franz Walter, 34, Southampton-buildings, London. (Complete specification.)

7167. **Improvements in electric arc lamps.** Thomas Harden and Frederick Ernest Pearl, 38, Holborn-viaduct, London.

7168. **Improvements in and relating to voltaic cells.** Georg Wester, 191, Fleet-street, London. (Complete specification.)

7174. **Improvements in electric arc lamps.** George Sylvester Grimston and Ernest Perrett, 28, Southampton-buildings, London.

7178. **Improvements in dynamo machines.** Charles James Hall and Robert Hammond, 433, Strand, London.

SPECIFICATIONS PUBLISHED.

1890.

8474. **Electrical switches.** M'Evoy. 8d.

8534. **Secondary batteries.** De Bernardos and others. 4d.

8720. **Electromagnetic railway brake.** Walter. 8d.

9602. **Distributing electrical energy.** Siemens Brothers and Co., Limited (Siemens and Halske). 8d.

12,169. **Measuring electrical energy.** Desruelles and Chauvin. 8d.

20,115. **Coin-freed dynamometers.** Barrett, C. A and A. 8d.

1891.

3191. **Distributing electricity.** Dolivo-Dobrowolsky and others 11d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¼
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Overhead Wires.—The London Overhead Wires Bill was read a second time on April 30th.

Telephone at Belper.—A telephone exchange was inaugurated with great ceremony at Belper last week.

Aluminium.—A factory of 600 h.p. is being erected at Saint-Michel (Isère), France, for the electrolytic production of aluminium.

Lincoln.—The Lincoln Town Council withheld their consent for the erection of a pole at the corner of the street by the National Telephone Company.

Electric Light in Wales.—Mr. Graesser has had the electric light fixed at his residence at Argoed Hall, near Llanelly, and also at his chemical works at Cefn.

Canterbury.—The town clerk, at the Canterbury General Purposes Committee last week, mentioned that the Electric Light Bill had been read a first time on April 14.

Foreign Electricians.—The "Almanach Annuaire de l'Electricité et de l'Electro-Chemie," edited by M. Firmin Leclerc, gives the names and addresses of French, Belgian, and Swiss electricians.

Meritens Battery.—It appears that the patent of M. Pollak, of 1885, presents a striking similarity to the later one of M. Meritens, of which much notice has been taken in both foreign and home journals.

Spanish Cables.—The Spanish Government proposes to lay a cable from Bony to Fernando Po, the German Government continuing this telegraphic communication from Fernando Po to Cameroun.

Claybury Asylum.—At the meeting of the Asylums Committee of the London County Council on Tuesday, the report of the sub-committee as to obtaining tenders for lighting the Claybury Asylum was considered.

Newton (Devon).—The Newton Local Board has, on the motion of Mr. T. Martin, referred the question of public lighting to a committee, and it is being asked why should not the town, like Taunton, have the electric light.

Tramways in Belgrade.—A syndicate of Milanese financiers have obtained the concession for 45 years for tramways in and out of the town of Belgrade. The electrical engineers should see that electric traction is adopted.

Electric Shocks.—In the discussion on electric shocks last week, in Mr. Newman Lawrence's remarks, the sentence should read "although the pain experienced by the passage of such currents *may not be great*, the after effects might be serious."

Reciprocating Motor.—Mr. Van Depoele has invented a reciprocating electric motor with three solenoids and magnetic pistons working on one crank axle for electric railways. It is to work by means of pulsating currents.

Provisional Orders.—In the House of Commons on Monday, leave was given to bring in Bills to confirm provisional orders made by the Board of Trade, relating, among other places, to Preston, Whitehaven, Liverpool, and Toxteth Park.

Cambridge Scholarship.—The Clerk-Maxwell University Scholarship, given for the promotion of original research in experimental physics, especially electricity, magnetism, and heat, has been awarded to W. Cassie, M.A., of Trinity College.

Edinburgh and Paisley.—In the House of Commons on Monday, Mr. Caldwell, on behalf of Sir Michael Hicks-Beach, introduced a Bill to confirm certain provisional orders made by the Board of Trade under the Electric Lighting Acts, relating to Edinburgh and Paisley.

Stafford Lunatic Asylum.—The Sub-Committee of Visitors of the Stafford Asylum recommended to the Stafford County Council that improved electrical communication be supplied throughout the asylum, as well as additional fire appliances, at a cost not exceeding £600.

Lighting and Putting Out.—It is interesting to note the details of the charges for street lighting by gas in Manchester. The value of the gas consumed in street lamps is given as £29,000, and nearly another £14,000 goes in repairing, maintaining, lighting, and putting out.

Lecture on Electricity.—H. B. Hartley, Esq., solicitor, Whittlesea, delivered a very interesting and instructive lecture on Thursday last week, upon "Electricity," in the Public Hall, Littleport. Numerous experiments were given showing the development in electrical science.

Collision with an Electric Tramcar.—In a case tried before Mr. Justice Denman on Wednesday, a man named Sharp was awarded £20 and his wife £50 against the North Metropolitan Tramways Company for injuries received in a collision between the plaintiff's cart and defendants' electric car.

Telephone at Leeds.—It is proposed to establish a Mutual telephone company at Leeds on the lines of that at Manchester, and negotiations between its representatives, the National, and the Leeds Chamber of Commerce are progressing. It was stated no settlement would be satisfactory which did not considerably reduce the rates.

Lectures on Alternate Current.—A course of lectures will be given at the Central Institution by Prof. Ayrton, on Mondays and Wednesdays, commencing May 11th next, on "Elementary Portions of the Theory and Practice of the Electric Distribution of Light and Power by Alternating Currents." Fee, one and a half guineas.

Personal.—Mr. Percy E. Scrutton has ceased to have any connection with the Electrical Engineering Corporation, Limited (the secretary of which company he was until recently), and has accepted the position of manager to the London branch just opened by Mr. J. C. Howell, of Llanelly, South Wales, at 24, Queen Victoria-street, E.C.

Triple-Expansion Engines.—The principle of triple expansion has been applied to horizontal steam engines o moderate power—100 h.p. to 400 h.p., for instance—by MM. Sulzer Frères with considerable success, according to the *Revue Industrielle* of April 18, where illustrations are given. The progress of electric lighting in France has led to the extended use of these engines.

Electricity for Mining Engineers.—In his inaugural address before the Mining Institute of Scotland Mr. Atkinson discussed the subject of "Mine Engineering." During his lecture he remarked that the transmission of power by electricity would appear to be the new thing in mining, and said that some knowledge of electricity would be require of the colliery managers of the future.

Steam Engine Efficiency.—Those interested in steam engine efficiency—and who among electrical engineers is not?—should find an article of value in Prof. Thurston "On a Maximum Steam-Jacket Efficiency," in the *Journal* of the Franklin Institute, in which the discovery of the maximum efficiency of the steam-jacket is deduced from trials, and the best ratios of expansion are dealt with.

Sydney.—A Bill is to be introduced into the New South Wales Parliament next session to enable the Australian Gas Light Company to extend its operations to lighting with the electric light the streets and public places of the city of Sydney, and other places which the company has now the power of lighting with gas. The Bill will also empower the company to increase its capital to £2,000,000.

Crystal Palace Exhibition.—The proposed electrical exhibition at the Crystal Palace will be a winter exhibition, and is to be opened in November next, and will be continued for some months. No charge will be made for space. Mr. R. Applegarth, 11, Queen Victoria-street, has been appointed assistant engineer to the exhibition. Applications may be made either there or to the manager, at the Crystal Palace.

Photography by Electricity.—The *Herald* states, according to a Reuter's telegram from New York, that a company has been organised at Cleveland, Ohio, with a million dollars capital to work a patent for taking photographs at a distance by means of electricity. We might suggest that the first use to be made should be to take a group photograph of the directors and promoters with a view to future proceedings.

Alternate-Current Motors.—At the last meeting of the Academie des Sciences, in Paris, M. Cornu presented a note by MM. Maurice Hutin and Maurice Leblanc, on the subject of their new alternate-current motor, which is stated to present the same advantages as the continuous-current motors from the point of view of power and efficiency, and allows the alternate current to be utilised for transmission of power over long distances.

Gloucester Guildhall.—The Municipal Buildings Committee reported at the Gloucester City Council last week, that on April 2 the architect accompanied the committee on their making a detailed inspection of the works, and they authorised certain extras. The architect conferred with them as to the desirability of wiring up the building, so that electric lighting might at any time be adopted without cutting about the building; but owing to the heavy cost of the work the consideration of the matter was postponed.

Leeds.—At the Leeds County Council on Wednesday it was stated that the electric lighting of the municipal buildings had cost £426 more than had been expected. Alderman Harrison, referring to the public lighting, said he considered the Yorkshire House-to-House Electricity Company fair and satisfactory all round, and he hoped within a reasonable time a large portion of the centre of the town would be supplied with electric light. The company have expressed their intention to push their work with utmost speed.

Electrical Standards.—A meeting of the Electrical Standards Committee was held on May 4, at the Board of Trade. The following members were present: Mr. Courtenay Boyle, Major Cardew, R.E., Mr. Graves, Mr. Preece, F.R.S., Sir Wm. Thomson, F.R.S., Lord Rayleigh, F.R.S., Prof. Carey Foster, F.R.S., Prof. Glazebrook, F.R.S., and Dr. John Hopkinson, F.R.S. Prof. Silvanus Thompson attended and gave evidence on behalf of the London County Council.

Lambton Castle.—The Earl of Durham has decided to thoroughly reorganise the electric lighting arrangements at Lambton Castle. It having been found that the existing machinery is of insufficient power to light the Castle satisfactorily, an entirely new electric generating plant—comprising two Cornish boilers, each of 25 nominal horsepower, and two Parsons steam turbines and dynamos of the new improved type, each capable of supplying 32 kilowatts—is to be erected.

Electric Tramways for Halifax.—A scheme is on foot for starting electric tramways for Halifax. As at present sketched out, whether the trams be worked by electricity or by horses—a point that seems not to be definitely agreed upon—several branch routes will be simultaneously worked. A meeting of gentlemen interested will be held shortly to consider the project. It is to be hoped that the opportunity will be taken to convince them of the advantages of electric traction.

Opera by Telephone.—The transmission of the songs from "The Gondoliers" by telephone from the Savoy Theatre to the Nautilus Swimming Club, on Tuesday night, at the Masonic Hall, Camberwell, provided an interesting entertainment. Some 40 pairs of the new consolidated double-pole Bell instruments were supplied by the National Telephone Company, and the guests were admitted in succession to hear short portions of the opera. The dialogues, songs, and choruses could be distinctly followed.

History of Electricity.—Mr. P. F. Mottelay, in the *Electrical World*, April 18 and 25, gives a "Chronological History of Electricity, Galvanism, Magnetism, and the Telegraph, from B.C. 2637 to A.D. 1888," copyrighted. It consists, so far (part I.), of a wonderful and no doubt interesting concatenation of excerpts (with portraits) from Aristotle, Thales, Madame Blavatsky, Lucretius, Pliny, and also the Talmud, giving quotations as to native magnets and amber, adamant and tournaline, with a vast array of quotations and references.

Paper on Accumulators.—A paper will be read before the Junior Engineering Society on Friday, May 15, at 8 p.m., at the Westminster Palace Hotel, Victoria-street, on "Electrical Storage Batteries," by Mr. H. B. Vorley, A.I.E.E. The synopsis shows the paper will deal with early forms, chemical action, charging voltages and currents, capacity, grouping of cells, disorders of cells, recent types, cost of batteries, and prospects of future development. The paper will be illustrated by diagrams, specimens of battery plates, and other apparatus.

Old Students' Association.—A paper will be read at the Central Institution, Exhibition-road, S.W., on Wednesday, May 13th, 1891, at 8 p.m., by Ernest B. Vignoles, member, on "Some Researches in Electromagnetic Induction," describing an original method of obtaining force induction curves, for iron or other materials, for use in predicting dynamo characteristics, transformer actions, or the induction in magnetic circuits of any other kind, together with tables and curves showing typical results for various kinds of iron and steel.

Westminster Hall.—It being stated that the waste products of the consumption of gas are having a deleterious effect on the ancient wooden roof of Westminster Hall in the Houses of Parliament, the First Commissioner of Works (Mr. Plunket) is to be pressed in the House of Commons to consider the advisability of substituting the electric light. We see it stated that if this is the case the ventilation of the hall will have to be considered, as this is now carried out by the use of gas. The introduction of one or two electric motors and fans may possibly be the solution.

Invention of the Electric Motor.—Some interesting letters, part of the correspondence between Thomas Davenport, the inventor of the electric motor in America, and Hon. Elijah Paine, justice of the New York Supreme Court, are given in the *Electrical World* (April 25). These letters, four in number, written half a century ago, contain much of interest with reference to the early history of the electric motor. He writes with reference to the flow of magnetism in his bolts, comments on the discovery of the upholding of a bar of iron in a solenoid, prophecies he will soon make a 1 h.p. motor, and maintains that Prof. Morse's electric wheel is an infringement of his own patent.

Manchester Town Hall.—The Gas Committee of the Manchester Corporation have adopted a resolution on the lighting of their Town Hall. If, as recommended by the Town Hall Committee, it is determined by the City Council to take immediate steps for the supply of the electric light to the Town Hall, they would remind the Council that to them has been deputed the carrying out of the provisional order for the supply of electricity within a certain area of the city, and they recommend "as a measure of economy and for other important reasons, that the instruction to at once proceed with the above installation be left in the hands of the Gas Committee."

Newcastle.—Under the arrangement recently entered into with the Newcastle and Gateshead Gas Company, it was understood that the Corporation should be at liberty to light such lamps with the electric light as they might think fit. In compliance with this agreement there has just been erected by the lighting section of the Watch Committee a large and powerful electric lamp on the North-road at Barras Bridge, opposite the end of Sandyford-road, the extra light thus furnished being such as will admit of the extinction of several gas lamps. Two corners of the railing surrounding the Grey Monument will also, we believe, be shortly provided with electric lamps.

The Metric System.—At one o'clock to-day a joint deputation from the Associated Chambers of Commerce and the Decimal Association will have an interview with Mr. Goschen and Sir Michael Hicks-Beach to urge upon them that the Government should take the necessary steps for rendering compulsory the adoption of the metric system of weights and measures, as the first stage in the introduction of a complete decimal system. The Decimal Association will be represented by Sir John Lubbock, Mr. O. V. Morgan, Mr. A. D. Provand, Mr. S. Montagu, and Mr. J. Rankin, among members of the House of Commons, as well as by other gentlemen; and a petition praying for the appointment of a Royal Commission or select committee will be presented to the Chancellor of the Exchequer.

Sims-Edison Torpedo.—The first exhibition in Europe of the Sims-Edison torpedo lately took place at Havre, on the coast of France, and with success. Representatives of the English, French, Spanish, Russian, Italian, Turkish, and Japanese Governments, and the principal daily papers, watched a semi-public trial last Saturday at the same place, the guests of the Société des Forges et Chantiers. Mr. Sims was in charge of the switchboard, and directed the operations of the torpedo, which made a long circuit and returned towards shore. Unfortunately, the slipping of the dynamo belt, through extraordinary carelessness, marred the complete success of the exhibition; but this was remedied, and the speed and complete submission to the will of the operator were clearly demonstrated.

Bath Electric Light Works and the Telephone. Mr. H. G. Massingham, the proprietor of the Bath Electric Light Works, is again confronted with a difficulty in respect of his supplying the city of Bath with a satisfactory illuminating power. This time the opposition comes from the Western Counties and South Wales Telephone Company, who assert that the working of the dynamos affects the workings of their telephonic system. An injunction to prevent Mr. Massingham continuing his supply of electric power for the purpose of public and private lighting is to be applied for. Mr. Massingham will contest this application and has taken the bull by the horns in issuing an advertisement calling attention to a new telephonic system arranged and worked under his own direction and control.

Railway Signalling.—At the meeting of the Cleveland Institute of Engineers last week, Mr. W. G. Cudworth, of Darlington, read a paper on "Railway Signalling." After description of the ordinary signalling, details were given of electric arrangements invented by Mr. Otley, signalling superintendent of the North-Eastern Railway, one of which was a repeater for indicating when a lamp went out by means of the contraction of a brass cylinder inside the lamp. Mr. Otley had also designed a very simple and ingenious electric point indicator, and a considerable number of these had been put in use for some time and had given satisfaction, but, the author remarked—we do not know with what justice—that "electricity is an agent not smiled upon by the Board of Trade." The arrangements in respect to level crossings and fog signalling were also described.

Roundhay Tramway.—Mr. Baker, agent to the Thomson-Houston Company, has asked the Leeds Highways Committee to consent to a tariff of 1d. per mile (*i.e.*, 2d. for the journey) with workmen's trains morning and evening at 1d. the whole way, and the committee have acceded to the request. Adverse criticism was made as to the long time the negotiations have been kept hanging on. As to the length of concession, Alderman Firth stated the company would be permitted to run cars until the tramway company's lease ran out in August, 1892, and to any further date agreed between the Council and the electric car company. The cars will be run from seven in the morning till eleven at night. If the cars were run they would give Leeds a unique position; they would give a chance of testing whether electricity as a motive power was of any service, and that would be of far more importance than the charging of even 3d. per mile.

Telephonic Facilities.—The Western Counties and South Wales Telephone Company is about to add another to the list of advantages offered to subscribers. The directors had already inaugurated a system of free passes to subscribers and their representatives, enabling them to speak from call-rooms in their own towns, and in December the passes were made available for local communications from any call-room in any town in the company's district where the holder might happen to be. An extension of the same principle is contained in the offer now made by the directors to lady members of subscribers' families, of a "lady's complimentary call-room pass," conferring on the bearer similar privileges to those given by subscribers' passes. It will be surprising to most people to learn that at Torquay exchange alone the calls average 600 daily. The company is now about to connect Exeter with their South Devon district.

Sulphate of Copper Battery.—We see M. Perreur-Lloyd, or rather his system, has turned up again. We visited his installation in a street out of Holborn a year or so ago, but have heard nothing since. This week M. Marcel Gaupillat has an illustrated article in *L'Electricien*, in which details of the process are given, and the cost per horse-power hour is stated as 10d., and the cost per 10 candle-power hour as 0·4d. It may be remembered that M. Perreur-Lloyd's idea was to manufacture sulphate of copper and other crystals, and in the process have electric current as a kind of by-product. An installation, it is stated, in the Council-room of the French Minister of War has been lighted for three months by these batteries, charging a set of 30 accumulators of 240 ampere-hours capacity. These are charged by a current of 12 amperes from the sulphate battery guarded by an automatic connector. The lamps are lighted at 55 volts.

Electric Traction in the Midlands.—The directors of the South Staffordshire Tramway Company have issued a pamphlet in which are set forth, from various points of view, the advantages of electric traction over steam traction for tramway purposes. After stating that there are many considerations which make for the final and complete superseding of the latter method by the former, and that the authorities both of Glasgow and Leeds have extensive schemes in hand, the directors add that they have seriously considered the objections raised by the local authorities to the use of steam, and, after carefully investigating the various other methods of traction, they are prepared, with the consent of the local authorities concerned, to recommend their shareholders to equip the tramway from Bloxwich to Wednesbury, *viâ* Walsall, on the overhead system of electric traction.

Japanese Steamer.—Messrs. J. D. F. Andrews and Co. have added another vessel to their list of electrically lighted ships in the new Royal mail Japanese steamer "Genkai Maru," which has been built by Messrs. Napier, Shanks, and Bell. The principal feature of the installation is the system of wiring, which is Andrews's concentric system. The advantages of this system are stated as completely embodying all the features of both double and single wire systems, thus avoiding the danger of affecting the compasses, besides introducing the important feature of safety from fire which is secured by this mode of construction of the cable. The wiring is exceedingly neat in appearance, and very easily laid over moulding and panellings, a matter of considerable importance in ships, where it is desirable to have every conductor in view. The dynamo, which is for 150 lamps, 16 c.p., is driven direct by an open vertical engine, fitted with a Pickering governor.

Starting at Southampton.—The inauguration of the Southampton central electric station took place on Monday of last week. The chairman of the company, Alderman J. Miller, and the directors entertained at a banquet a number of gentlemen on the occasion. Miss Amy Miller switched on the light, and the central station, several places of business, and the Bargate were lighted up, the starting being the occasion of great interest to large crowds of spectators. Mr. J. G. W. Aldridge the engineer to the Southampton Electric Light Company, has been responsible for the plans of the station and the mains, the contractors being Messrs. Crompton and Co. The company started with five orders, and have some score or so of orders now on hand, and more promises. The new pier now in progress, and the Town Quay, are to be lighted from the central station, while, as we mentioned last week, the cranes required on the quay will also be worked by electricity from the company's mains.

Royal Society.—The annual *conversazione* of the Royal Society was held on Wednesday evening at Burlington House, the president, Sir Wm. Thomson, and the council being the hosts. Profs. Rücker and Thorpe exhibited a map of probable magnetic lines, and Mr. Shelford Bidwell had his ingenious selenium automatic electric lamp-lighter, and a selenium alarm for calling attention to the accidental extinction of ships' or railway lamps. Messrs. J. E. H. Gordon and Co. had on view a Tomlinson regulator for electric light mains, for which many advantages are claimed, amongst others a considerable saving in fuel. Prof. Oliver Lodge had a revolving mirror and a clock for indicating the earth's orbital revolutions. Mr. W. Crookes exhibited some of his striking experiments of phosphoresce in high vacua. Messrs. Richard Frères showed their recording instruments, and Mr. Killingworth Hedges his electrical safety valve. Prof. Silvanus Thompson had an ingenious focus measurer for testing lamps.

Electrical Coal Explorer.—M. Trouvé's "Erygmatoscope" is about to be used, says Mr. André in the *Colliery Guardian*, in a boring for coal in the Boulonnais district, now being explored. This instrument consists of a very powerful electric glow lamp enclosed in a metal cylinder. One of the two hemi-cylindrical surfaces constitutes a reflector; the other is of thick glass, over against the point of light. The bottom of the cylinder, inclined at an angle of 45deg., is an elliptical mirror, and the top is open to permit of observations being made. These observations are made from surface through a telescope, the lamp being so mounted that its rays are intercepted in the upward direction. The whole of the apparatus is suspended in the borehole from a cable, composed of two insulated conducting wires, which may be wound on a reel, and thereby lowered and raised as required. The electric current is obtained from a portable battery specially designed for the purpose by M. Trouvé, whose achievements in this direction are well known. It is said that at a depth of 300 yards a seam of coal or rock stratum may be minutely examined. This instrument, says our contemporary, is likely to be of great service in prospecting operations.

Nottingham.—The Nottingham Town Council, on Monday, held a short meeting in committee, when it was resolved that before letting the contract for the supply of electric light in the borough, the special committee appointed to take charge of the matter should be allowed to engage professional assistance. The Council then rose. In the matter of electric lighting Nottingham has lagged behind other towns of similar size and importance, but during the last few weeks business premises in one of the main thoroughfares of the town have been lighted up with exceedingly satisfactory results. A house in Talbot-yard, off Upper Parliament-street, has been converted into an engine-house, wherein a plant has been laid down capable of supplying 600 lamps. A Marshall's engine, formerly used at the Savoy Theatre, has been put down, and is capable of developing 60 h.p. The engine drives, by link belting, a Westminster dynamo, manufactured by Messrs. Latimer Clark, Muirhead, and Co., the identical dynamo which secured a gold medal at the recent Paris Exhibition, and the fittings have been supplied by the Electric Wiring Company, of London. Various tradespeople, as well as the Talbot Restaurant, are served with the electric light, and the installation has proved a thorough success.

Berwick-upon-Tweed.—The Lighting Committee of the Urban Sanitary Authority have reported that, according to instructions, they have fully gone into the matter of lighting the town. They found that the gas company were not disposed to meet them either in price or quality of the gas. They considered the question of erecting gas works for themselves, but they were of opinion that the electric light was the light of the future, and as immense advancements had been made in its application lately, they directed their attention more particularly to it. The committee put themselves into communication with several electric light engineers, and the result is that one firm of electric engineers has offered to undertake to erect, work, and maintain an electric light installation for a period of five years at a cost which will only increase the general district rate 1½d. per pound, in each half-year, more than it is at present. This firm will also erect, work, and maintain sufficient power to supply all the shops, etc., the proprietors of which may wish to take advantage of it. This they will do at a reasonable price. The proposed installation for this town to consist of 21 arc lamps at 2,000 c.p.

nominal, and 20 20-c.p. incandescent lamps. The committee are unanimously of opinion that by the introduction of the electric light to Berwick-upon-Tweed it will, upon the present system, be as great an advance as 70 years ago gas was over the old whale-oil lamps, and will give Berwick-upon-Tweed a standing above what it has at present.

Naval Exhibition.—The Royal Naval Exhibition at Chelsea was opened on Saturday, and should prove a very captivating sequel to the long series of similar exhibitions, from the fact that, of all subjects, naval matters interest all good Englishmen. The electric light is, of course, well in evidence. The generating plant comprises seven Paxman locomotive boilers, six Willans engines, driving five continuous-current Siemens dynamo, and one alternator by Messrs. Siemens Bros., who carry out the whole of the lighting. The plant has been arranged on the plan of a compact central station; three of the dynamos give each 1,500 amperes at 120 volts, absorbing 260 h.p. each, coupled direct to the Willans engines. There are two smaller sets as used in the Navy, consisting of 200 and 400 ampere dynamos respectively, coupled direct, one to a Willans open type vertical and the other to a Willans G.G. engine. The Siemens alternator is used for lighting the immense arc lamp placed at the top of the model Eddystone lighthouse, and provides 500 amperes of current. The mains cover the whole ground with a network, and consist of Siemens lead-cased and iron-sheathed cables. The general lighting is carried out by means of 200 Siemens new pattern 9-ampere arc lamps, carried in the grounds on 40ft. lattice iron masts in groups of six. In addition there are a large number, about 2,000, incandescent lamps in the dining-room and offices, and the current will also be kept on all day to work numerous electric motors in various parts of the building.

Heckmondwike.—The provisional order for the supply of electric light at Heckmondwike passed last week the standing orders of the House of Commons. The committee of the Heckmondwike Local Board have received several rough estimates, but have not yet consulted professional advice. The best course as an experiment, they consider, would be to put down an installation of about 600 lights of 16 c.p. for the purpose of supplying the public lamps in the centre of the town to the extent of 150 lamps, and leaving one-third to one-half of the capacity for the use of private individuals, and to leave the lighting of the remainder of the town until the Board were satisfied of the success of this experimental plant. The information the committee have before them results in their report in a rough estimate of the probable cost and results as below: Engines and dynamos in duplicate, boiler (single), posts, cables, lamps, and all other plant and fixing, £3,000; buildings, but not land, £600; total, £3,600. The yearly cost of working on this basis would be about £604. The probable results on the other side are given: Cost of supplying the lamps in the district with gas, £200; lamp lighting saved, £80; interest and depreciation on, say, £300, at 10 per cent., £30; repairs, renewals of lamps, and other maintenance, £70; receipts from supply of 300 private lights of 16 c.p., at £1. 1s., £315; total, £695. They find that the usual charge for private lighting is, if taken at so much per lamp per year without meter, 25s. per lamp of 16 c.p. If taken by meter the charge is usually at a rate of 8d. per Board of Trade unit, and this appears to be equal to gas of 17 c.p. at about 3s. 9d. per 1,000ft. They report that they find at all the stations for public lighting visited—viz., Bradford, Kensington High-street, and Kensington House-to-House plant—no consumer ever goes back to gas, while the increase of electric lighting is steady and rapid. In consequence of engines and dynamos having to be in duplicate, and this not being required in future additions, the proportionate cost of this plant is much greater than future additions would be. The next 600 lights would cost from 25 to 33 per cent. less than the first. Offers have already been received from firms or companies to take over the powers, lay down the plant, and work the same.

Electric Tramways for Wednesbury.—At the meeting of the Wednesbury Town Council held on Monday, the town clerk announced that he had received a letter from the South Staffordshire Tramways Company asking the Council to sanction the introduction of a system of overhead electric traction for the working of their lines, the company being prepared to adopt such a system for the line from Wednesbury to Bloxwich *viâ* Walsall. He also submitted pamphlets and tracings which had been forwarded. Alderman Williams proposed that the application be acceded to, subject to an agreement between the company and the Council. He said many people complained of the abominable nuisance of the present steam trams; and the company were prepared to spend from £18,000 to £20,000 in introducing a system of electric traction, which would obviate all the nuisances complained of. In America these electric lines were to be numbered by the scores if not by the hundreds, and they were very successful there. One of the objections raised was that there was peril to life and limb, and it was true that they heard of accidents from the rupture of electric wires, but those were always in the case of wires for lighting purposes when the pressure used was high. For traction purposes the pressure required was only 200 volts, from which there was no risk; and seeing that the wires were to be ⅜in. thick, the probability of an accident from the fall of a wire of that size was very remote. The weight of the car would be materially reduced, reducing the shaking which attends the passage along the streets, noise would be minimised, smoke and sulphur fumes would be done away with; and the poles, instead of being unsightly, would be ornamental, and in due course would no doubt be utilised for the lighting of the streets by electricity. For all the reasons named he appealed to the Council to sanction the alteration proposed, and take a leading place in promoting the introduction of the new mode of traction. The ex-Mayor (Alderman W. Lloyd) seconded the motion, for the reasons named by the preceding speaker, and also for the additional one that the tramway company had found the use of steam so expensive that, although their receipts last year amounted to £3,500, they reaped no advantage from the increase, owing to the great cost of repairs of engines, and the heavy outlay in fuel. He supported the proposed change because it would be a great benefit to the town, and because it would help the company, whose cars had become almost indispensable to immense numbers of persons. Mr. Handley thought the Council should refuse to entertain the application until the company had fulfilled a promise made some years ago to contribute £500 towards the cost of widening the street. Alderman Williams announced that he something quite satisfactory on that point. Mr. Oldbury thought there ought to be a conference upon it with the Walsall Town Council. Mr. Hackwood also advocated a postponement of the matter, for the purpose, among others, of a conference with the Walsall Town Council. Ultimately the motion was amended, to the effect that the application should be granted, subject to a proper agreement being prepared, the conditions to be inserted in it to be referred to the General Purposes Committee. In that form it was carried unanimously, the Mayor, in answer to a question, stating that the committee would have [illegible]er to confer with the Walsall authorities [illegible]

AUTOBIOGRAPHY OF SIR F. RONALDS.

As will be seen, the following was written by Sir F. Ronalds from Padua. Parts have been published before, but we believe the whole will be found interesting.

Padua, Feb. 21, 1860.

MY DEAR CARTER,—This is the seventy-second anniversary of my birthday, in 1788.

At Dr. Phillips's seminary, at Walthamstow, I acquired a little taste for physics, he having a good collection of instruments, etc., and a smattering of geometry, but on my removal to Mr. Cogan's, at Cheshunt, I found that he hated Euclid as much as he loved Homer; so my principal scientific studies here were devoted to the service of a mouse-trap company, of which David Martineau was the treasurer, and to which my brother Edmund held the office of tamer. We succeeded very well until no mice remained to be caught.

At the age of about fifteen I was consigned to the desk, and so on.

At about nineteen I lost my father, and the very severe task of managing a business which then returned at least £150,000 per annum devolved upon my overloaded shoulders. The first year terminated very successfully, but the proceedings of a speculating Quaker, who long after ruined himself and died in a madhouse, and who was *quasi*-trust upon me as a partner, together with a disgust of trading habits and a *penchant* for other pursuits, etc., soon caused me to steer a different course.

Very early in life chemistry was my chief amusement, and my most memorable performance in this science then was the blowing up of a large hydrogen gasometer in the breakfast-room of No. 1, Highbury-terrace; the immediate consequence of which clever achievement was the transfer of my studio to a small cockloft over the coach-house.

Here, through a round hole, a window, in the south wall, I introduced one end of a long wire, extended down the fields towards Holloway, not then built upon, and insulated it in a new manner, called Singer's, but originally mine, on high poles. With this, with pith-ball electrometers, bells, etc., I made a few unimportant observations of Beccaria's kind, and only mention them because I think that the idea of transmitting intelligence, by discharging an insulated wire at given intervals, first occurred to me whilst thus occupied.

Mr. Cross, a patron of Singer, made experiments at about the same time and in the same manner on a very extensive scale; but I desisted, because the neighbours were occasionally affrighted by very loud detonations, and said that they should be killed by "the lightning which I brought into the place." In fact, two or three of my neighbours were killed; but these were only unprincipled rats who were experimented upon, dwellers in the hayloft, and devourers of my pony's corn.

In about 1813, I fitted up at Hammersmith, Upper Mall, a more elegant hayloft, and a small apparatus, but with the addition of a series of registering electrometers, as described in "Singer's Elements of Electricity," his notice of which, and a slight mention of the Highbury wire, in "Brewster's Encyclopædia," gave me a little encouragement. Becoming, however, dissatisfied with the mode of insulation hitherto used, I devised, and Mr. Brande kindly printed and figured, in his "Quarterly Journal," vol. ii., p. 217, the mode which I used at Kew afterwards.

In 1814, I happily became acquainted with my kind old friend, M. De Luc, and made experiments on his dry column, which have some relation to the still-vexed question of chemical action and contact. These were printed in the *Phil. Mag.*, 1814, vol. xxiv., June, September, and December.

A little summary of them appears in a note at p. 64 of my "Description of an Electric Telegraph," and, if Mr. Walker is the learned and experienced electrician, I should be obliged by his perusal of that note, because I think that those experiments were the first in which the distinctions between quantity and intensity was observed; terms which have ever since been much employed. He would perhaps find me in error.

They led to my invention in 1815 (*vide Phil. Mag.*, vol. xlv., March) of some wheel-work set in motion by six electric columns, made by Singer, and which columns are now at the Kew Observatory, and still, I believe, active. They were so in 1851. This Mr. Tilloch, the editor, called, erroneously, a galvanic clock.

In 1816 I set in motion a timepiece compensated for the effect of changes of temperature upon electric columns. In attempts to measure time by the electric column I was, however, forestalled by foreign electricians.

In the same year, amid many scoffs and jeers and a few imputations of insanity, I worked hard at the electric telegraph in the garden at the Upper Mall, Hammersmith. "Well, but, joking apart," said Mr. Carr, a sensible old gentleman, before the experiments were completed, "do you really wish to convince me that you can send me a message from London to Petersburg in 10 minutes?" "No," was the reply, "my only wish at present is to convince myself." I would here beg leave to refer to a little footnote (containing an Irishism) at p. 23 of my "Description," etc., relating to my application to Government.

Much has been said about my difficulty of insulation by those who are not readers of Beccaria's, Volta's, Wilkie's, Œpinus, the great Lord Stanhope's, and other's writings on *Electricitas Vindex*, etc., and who do not seem to be aware of the facility of insulating conductors circumstanced as my buried wire was—*i.e.*, serving a like office to that of the interior coating of the Leyden jar, or the shield of the "perpetual electrophorous"; which last is well known to retain a charge for months—aye, years—although both its coatings may be in conducting communication with the earth and with each other. The buried wire actually retained a part of the charge too long sometimes, and even a small renovation of signs, due to certain effects of humidity, I believe, sometimes occurred spontaneously. This was a slight but real objection, about equivalent, perhaps, to that arising from the retention of magnetism in the electromagnetic telegraph.

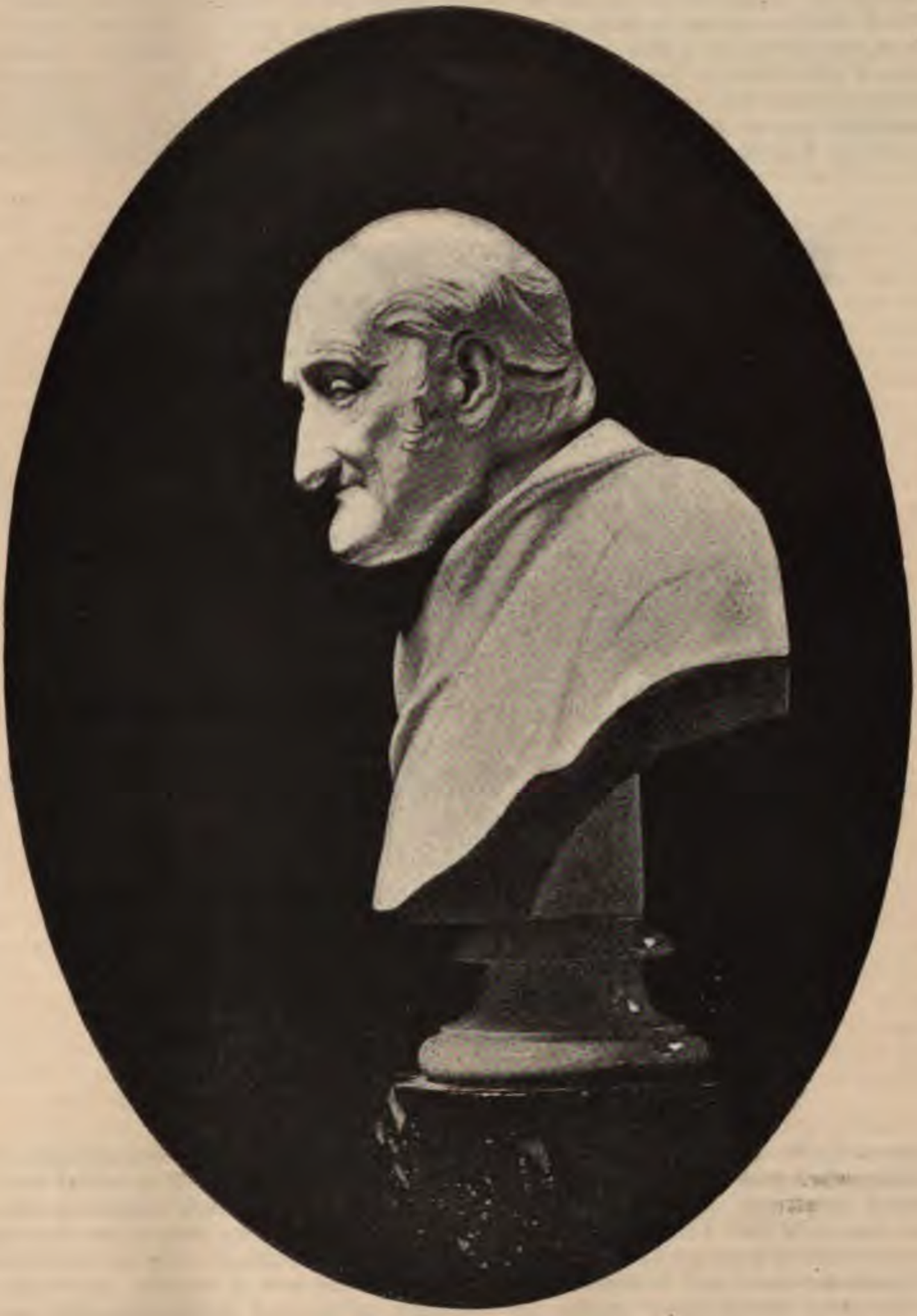
I am fully aware that what I have now said is open to discussion, but this is not the place for it; and I am very far from advocating the cause of static, in lieu of magnetic, electricity for telegraphic purposes. Sufficient, not perfect, insulation could be attained, and a provision was contemplated "for keeping up a sufficient and constant supply of electricity," in my book, p. 21; and I will say that if the electric telegraph of 1816 had been fairly examined, an effective instrument might have been in the hands of the Government, and that after Dr. Œrsted's experiments, an improved telegraph might have been in the said hands; also that messages might have been conveyed thereby as cheaply in England as they are in America "a'most."

On some day before September, 1818, Mr. Cooke's father, a surgeon of Brentford, happened to visit us at Hammersmith, when I showed him and explained my telegraph. I believe he said that he said that he would mention it to his son, who was then in Germany. He was, you know, Wheatstone's early partner. I became acquainted with Wheatstone in about 1820, I think. Not having proper papers here I cannot name the precise time. You must excuse all this egotism, my dear Carter; I cannot avoid it.

In about 1817 a warmed electrical machine, a resinous-plate electrograph, a pendulum doubler moved by a clock and capable of charging the telegraph, each described in "The Encyclopædia Britannica" and in the "Description," together with many undescribed affairs of a like kind, were devised and executed.

During 1818-19-20 I worked in Italy on a "Bibliography of Electricity and Magnetism," collecting books and notices of books, etc. Made a few electrical experiments on Vesuvius during an eruption. Prosecuted a sketching tour in Sicily with Sir Frederick Henniker, when we both became aware of the great advantage derivable from the use of mechanical sketching instruments. Visited Egypt, where I got some teeth knocked out. Became a Hadgee for your amusement at Jerusalem. Bathed in the Jordan, near which Sir Frederick got an ear nearly cut off, and called upon Lusieri at Athens, the best sketcher in the world. What has become of his unrivalled performances?

In 1821 I spent much time upon drawings from the foreign sketches, and on the journal which I had kept, endeavouring vainly, and in vain, to render them and it a



RONALDS, FROM BUST.

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little amusing. Sir Frederick Henniker succeeded in producing a very pretty book.

In 1823 I had a little better success in the "Description of an Electric Telegraph," etc., so often alluded to; but it was written in great haste, and in love; and I went abroad again with a very unscientific object in view.

In 1824, *et seq*, I devised two perspective instruments; one for drawing *dal vero* and the other from plans and elevations; also a staff for the support of the former, *vide* a little pamphlet entitled "Mechanical Perspective." I was long occupied in London, Birmingham, Croydon, and Chiswick in contriving mechanisms for and in superintending the manufacture of these patented affairs. Many of the first kind, patronised by you, by Lord Stanhope, and by other good friends, were sold by Cory and others, until photography opposed an obstacle; but the hexipod staff, consisting of three pairs of legs and a bar, or roller, forming (each pair) a triangle, etc., has been to this time very extensively used for supporting many other kinds of instruments requiring great stability.

RONALDS, FROM PHOTOGRAPH.

Influenced by suggestions of his Lordship, in the course of a very kind and flattering correspondence, I constructed an instrument for panoramic sketching, and for employment in copying upon walls and upon theatrical scenery, greatly magnified views executed in *piccolo* and *dal vero* by its means, or otherwise. Part of it was like a very old machine (false for plane perspective), invented by Ignatius Danti as a plane perspectograph merely. It was in either the first or second locality of the Polytechnic Institution, and is now, with much other such lumber, at the Pantechnicon.

When the Polytechnic Institution was first established in the haylofts, etc., of the old King's-mews, now the site of the picture gallery at Charing Cross, I was asked to contribute towards the object of it, and (having a great *penchant* for haylofts, you will say) placed six or seven little things there, such as a new forebed for carriages, a new instrument for describing the ellipsis and the conchoids, an addition to the slide rest, used much now—*vide* Holzapfel—in turning curved surfaces, a semi-transparent sun dial, showing mean time, and the perspective instruments. I cannot remember whether one or two other articles were there or not. They were all put into the descriptive catalogue.

I believe that a model of what I called a telegraphic clock was not there. It indicated the time by variations in the height of one of three large black balls visible at great distances.

When this institution was removed to its present site near Cavendish-square, I sent there a self-acting fire alarm (now at Kew), which I mention chiefly for the sake of venting a little spleen.

Verily, we schemers are not always very honest.

A gentleman had another fire-alarm there, and mine happening to be the best, the ticket on it was removed from the one to the other. A similar kind of manœuvre was executed at the great Paris Exhibition of 1855. The number, or ticket, of my barograph was exchanged for a number tending to show that it was an invention of my rival, Mr. Brooks; and curves produced at the Radcliffe Observatory, Oxford, by my instrument, were shown by M. Le Verrier, at the French Institute, and taken by many for Mr. Brooks's curves. With the aid of the Abbé Moigne, this mistake was detected and rectified.

At the time of Sir James South's dispute with old Troughton, about a very large and costly equatorial, I presented to the former a model of an equatorial formed on the principle of the above-mentioned hexipod staff. This was placed before certain arbitrators on the occasion, and afterwards the Northumberland equatorial, at the Cambridge Observatory, was constructed on a plan very much resembling that of this model: not improved, I think; but I may be naturally prejudiced.

Between 1830 and 1836 I wasted much time and labour in a journey to Brittany, and in contributing drawings, plans, and descriptive matter, to a, I believe, still unfinished work on the Celtic remains of Carnac. In the course of this period I furnished also part of, and edited, a little work of my brother Alfred, entitled, "The Fly-fishers' Entomology," which succeeded tolerably well; it having reached four or five editions; but these matters [illegible] out of my line, in 1842, I determine [illegible] meteorological pursuits [illegible] tion of the har [illegible]

Observatory, under the auspices of the British Association. My first care here was to insulate, by a modification of the means which I had devised before, and projecting from the dome of the equatorial apartment, a very high voltaic conductor, and to provide it with improved and new electrometers, etc. (*vide* Kew Reports, 1843 ?). It may be said that this apparatus was constantly electrified during eight years with a few very small intervals of transition from a positive to a negative state, and a few days for repairs, etc., and that the results of 15,170 observations made in five of these years consecutively, taken in conjunction with the observations of Mons. Quetelet, of the Brussels Observatory, and with those of Mons. Lamont, of the Munich Observatory, etc., have contributed notably to the advancement of our atmospheric electrical science.

Had not mean molestations intervened in 1851-2, I think that I should have been enabled to elucidate a little the subjects of atmospheric electromagnetism, and the aurora, by its and by other means.

Soon after its completion, I was consulted as to the adoption of similar arrangements at the Greenwich Observatory. In consequence of certain local and other inconveniences, my methods of observation were here disadvantageously modified; the conductor was, therefore, not constantly charged, but improvements were subsequently made, and I trust that the observations recorded in the Greenwich tables will not be found useless.

A complete apparatus and instructions were sent to the Madrid Royal Observatory, and others to that of Bombay, etc. The director of the former made good use of his instruments immediately, and has recently sent me an academical memoir (to Kew) on the subject, which I have not seen, but which doubtless contains valuable matter, for his building and the region of it are eminently adapted to such researches.

I will not dwell on various other instruments, described in my first, and in some other reports (of Kew), as an anemometer, a new, simple wind vane, a new, very delicate atmidometer, or "vapour gauge," a storm clock for facilitating the registration of very sudden meteorological events, etc.

In April, 1845, I was the first to employ photography in self-registration by meteorological and other instruments generally, and I constructed in that month a photoelectrograph. This was followed in December by a declination magnetograph, by a barograph, and by thermographs, wet and dry. These inventions were kindly and liberally patronised by the Royal Society, of which I had become a member, and they were described in the *Philosophical Transactions* for 1847, Part I.

But there are, as we all know, great objections to a syphon barometer (the kind which I first used); therefore in the same year (1845) I began the construction of a cistern instrument, and this barograph was compensated for temperature somewhat after the manner of the gridiron pendulum, rods of zinc, etc., being employed with multiplying levers to compensate the mercurial expansion.

In 1848 I improved the construction of the declination magnetograph, and made it applicable to horizontal force registration, using Dr. Lloyds's great amelioration of Gauss's system. Sent also a vertical force magnetograph to the Toronto Observatory, Colonel Lefroy, director.

In 1850-51 I modified M. Regnault's hygrometer, etc., by the employment of a new and more convenient aspirator, and improved it by other means; *vide* report for 1851, in which I also gave a description of an electrical observatory adapted to easy transport, and of some other modifications and improvements of electrical instruments.

I omit the detail of various other little devices in the reports, consisting in some new apparatus for the preparation of photographic plates; the use of gelatine paper for procuring impressions from the magnetic and meteorological curves, etc.; an instrument used in tabulating the ordinates of such curves, which was called the "ordinate board"; apparatus for determining the amplitude of the arcs described by the magnets, etc.

Neither will I tax your patience with various other Kew subjects not mentioned in the Kew reports, excepting one, relative to a proposed occasional substitute for the "captive balloon" in certain meteorological observations.

In 1847 (?) I attached three light cords to a kite and to three little stakes in the earth in an equilateral triangle. By this means it was retained at a nearly constant elevation, whereas even small increments of the wind's force produce great depression of the captive balloon. This rough experiment was described in the *Philosophical Magazine*, September, 1847 (?).

In 1852 I was annoyed and oppressed at Kew, and left Chiswick on the death of my mother; accepted a small pension from the Civil List for what, in the warrant, is much too flatteringly called "important discoveries in electricity and meteorology," and quitted a flourishing establishment of which I have been called the founder. This is not strictly true. In 1842 it was in dissolving embryo; but it is true, as General Sabine has said, that it would not have flourished but for my exertions. I maintained it against the strong opposition of many influential members of the British Association, and particularly of one who became, and is now, one of its most strenuous supporters.

The system now pursued at Kew is precisely that which I long since, in a document received by a committee, strenuously advocated. For the constantly kind, yet perfectly disinterested, and powerful support of Sir John Herschell and several other gentlemen, I shall ever feel grateful. The Royal Society has been very kind and liberal to me at Kew, and its late president, Lord Ross, particularly so.

In 1853, I established, at the Radcliffe Observatory, Oxford, by Mr. Johnson's request, an improved compensated barograph, and thermographs, dry and wet. These instruments—the former particularly—under Mr. Crooke's able management have produced, from the autumn of 1854, very satisfactory results, according to Mr. Johnson's descriptions of them.

I believe I may say inoffensively that the successful use of them investigated the prosecution of Mr. Johnson's ingenious and valuable course of observations made by self-registering instruments at his important observatory.

In 1854-5 worked hard in the Imperial Library of Paris on the "Bibliography of Electricity, Magnetism," etc., before alluded to; a labour which at sundry times, with long intervals, I had undertaken ever since 1815, and worked hard in dealing with the *bouquinistes*, who are almost as difficult rogues as horse-dealers.

Also produced, with the Abbé Moigne's and my nephew Edmund's assistance, chiefly "Descriptions de quelques Instrumentes meteorologiques et magnetiques," which is a condensed account of some of the Kew affairs with corrections and a few additions, and I gave the Abbé a little account of the barograph, etc., for his "Cosmos"

Since about the summer of 1856, I have wandered into many public and academic libraries and bookshops of France and Italy, gathering a little fruit to be added, on my return to dear old England, to the English, German, etc., store, but I shall rot long before my fruit is ripe.

You see that I am much embarrassed for want of correct dates, having no means of reference here scarcely.

Farewell, dear Carter; this long epistle of an old man is as short as dotage would allow him to make it, and written as plainly, in two senses of the word, as he could write it, in the hope of diminishing a little the trouble of selecting the very small amount of matter which may be subservient to Mr. Walker's purpose.

There is a "century of inventions" in commonplace, etc., not worthy of mention here or anywhere else perhaps.

Yours very sincerely,

FRAS. RONALDS.

RAILWAY TRAIN LIGHTING.*

BY WILLIAM LANGDON.

The desirability of a better illumination of railway carriages had been long felt. The lamps originally provided were intended simply to enable passengers to enter and leave the carriages without inconvenience, but the exigencies of the present time called for the additional luxury of a reading light. The illuminants in use were rape oil, paraffin oil, compressed gas, and electricity, and the author dealt with the recent advances which had been made in connection with the last.

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* Paper read before the Institution of Civil Engineers.

In October, 1881, a Pullman car, running between Victoria and Brighton, was lighted by electricity, and the experiment was so far successful that it was extended to the entire train, and at present there were 16 trains so lighted belonging to the Brighton Company. Mr. Houghton, the company's electrician, and the late Mr. Stroudley, were the pioneers of the application of electricity to this purpose.

An interesting experiment, devised by Mr. W. H. Preece, F.R.S., was tried on the London and South-Western Railway in 1883-4. The movement of the train was employed to compress air into a chamber, and the air so compressed was used to drive a dynamo to furnish a current for the lamps. In July, 1886, the Great Northern Railway applied electric light to one of their metropolitan trains. The Taff Vale and Cheshire lines had also made experiments in the same direction. In all these cases the lighting was effected by means of a dynamo driven from the axle of the guard's van combined with accumulators stored in the same vehicle. In August, 1884, the London and North-Western Railway tried a different principle in fitting up a short train, which was still running between Manchester and Liverpool. The current was produced by a dynamo driven by a Brotherhood engine fixed to the tender and supplied with steam from the boiler of the locomotive.

In this, however, as in the previous cases, the lighting was effected from one point, and should the train be broken up the part severed for the source of current would be left in darkness In 1888, the directors of the Midland Railway authorised the equipment of two trains to run between London, Manchester, and Liverpool, in which the following conditions were to be fulfilled—viz. : 1. Each vehicle was to carry its own lighting power. 2. Each vehicle was to be capable of being coupled and uncoupled and turned about as needed, without the possibility of the connections being wrongly made. 3. The coupling must readily draw apart when coaches were slipped *en route*. 4. The act of drawing the coupling apart must make all the changes in the connections necessary to transfer the lamps from the dynamo circuit of the train to the accumulator circuit of the carriage itself. 5. Each compartment was to carry not less than two lamps. 6. The lighting throughout the train was to be capable of being turned on or off from any one of the guard's vans. For the sake of experiment, one of these trains was equipped on the "parallel" system, the other on the "series" system. The former, having proved the best, had been adopted by the company, and there were now five trains leaving St. Pancras daily which were electrically lighted, and in which the dynamo was driven off the axle of the guard's van, each vehicle being provided with accumulators capable of supplying the necessary current without the assistance of the dynamo.

There was also a local train travelling between Manchester and Stockport lighted after the plan adopted by Mr. Houghton on the Brighton line, but equipped with two sets of accumulators and two dynamos driven from the axle. In addition to the foregoing, there were two trains running between London and Bedford, the dynamos of which were driven by small high-speed engines placed on the locomotive.

Dynamos.—In all cases where accumulators were employed, it was necessary (*a*) that the dynamo should automatically come into circuit when the requisite speed to enable the E.M.F. of the machine to overcome the back E.M.F. of the batteries had been obtained. (*b*) That the E.M.F. should remain practically constant whatever might be the speed of the train. (*c*) That the current should always be in one direction, whichever way the vehicle was running. The first trains fitted on the Midland Railway were furnished with machines giving a practically constant output of current, no matter how few or how many were the carriages attached. Messrs. Holmes and Co., of Newcastle, had since succeeded in making a dynamo which afforded a current proportional to the resistance of the circuit, and these machines were employed on all main line trains in which the dynamos were driven from the axle. Automatic apparatus effected the stipulated requirements.

Accumulators.—These were of the E.P.S. type. With main line trains, where each vehicle carried its own batteries, the type employed was C 15 for the larger, and C 11 for the smaller carriages. In all cases the electrical pressure was 35 volts, so that 18 cells were necessary for each.

Electrical Coupling.—Where trains were not broken up, the difficulty of providing an efficient electrical coupling was not so great, but where the marshalling of carriages had to be smartly dealt with at terminal or intermediate stations, the coupling must be such as not only to provide a good electrical connection, but to admit of easy handling. The form adopted by the Midland Company effected these objects in a perfectly satisfactory manner. On a coupling being separated, the lights were automatically turned on. If the lamps were not required, the coupling, instead of being allowed to hang down, was placed upon a "dummy," the effect of which was to turn the current off. For slip coaches special provision was made.

By the insertion of a small resistance in each battery parallel, a fair distribution of the current throughout the different vehicles was attained, and in order to meet the increased pressure when the dynamo was in circuit, a sufficient additional resistance was automatically introduced. The lamps were of 8 c.p., and there were two in each compartment, safety fuses being provided in connection with each group, as well as in connection with the dynamo itself. The circuits were arranged on the parallel system.

With regard to the second mode of generating the current—namely, by dynamos placed on the locomotive—it was believed that at present no other trains save the three already referred to were equipped in that way. Mention should, however, be made of experiments conducted on the Lancashire and Yorkshire Railway in 1884, and also, in the same year, by Mr. W. H. Massey, on the Metropolitan District Railway.

The extra staff required consisted, so far as the Midland Railway was concerned, of one senior officer and two train attendants at St. Pancras, one train attendant at Nottingham, Manchester, Bradford, and the services for about three hours per day of a man at Derby. The total number of electrically-lighted vehicles now in operation on the Brighton, Great Northern, and Midland systems was 365 coaches and 57 vans.

In conclusion, the author pointed out that the main points to be determined were whether electricity was safe, reliable, and less costly than other illuminants. The fact that electrically-lighted trains had now been running for a considerable period without accident would appear conclusive evidence of its safety, and experience had shown that there was no reason to doubt its reliability where efficient provision had been made; and the author believed that when the cost of applying any of the illuminants, whether oil, gas, or electricity, to a complete railway system was taken into account that the latter would be found most economical. The cost of oil was between ½d. and 1d. per lamp per hour. So far, compressed gas had never been employed for lighting the entire stock of any railway, with the exception of the Metropolitan Railway—which was specially adapted for its application. To consider the cost as applied to stock devoted to certain traffic would hardly afford a true basis of comparison. Where gas was used entirely, depots must be established at each point at which trains were made up, whilst at busy centres it would probably have to be conveyed some distance by pipes laid down for the purpose. The cost of fitting coaches for gas varied from £4. 8s. to £7 per lamp, while for electricity it was £50 for a six-bodied Midland main line coach, or £4. 3s. 4d. per lamp. For trains running which were not broken up on the journey the cost per lamp amounted to £3. 12s. or £18 per five-bodied coach. Vans with dynamos cost from £250 to £300 each. Statistics were given showing that the cost for maintenance in the case of gas was from ·045d. to ·250d. per light per hour. There was reason to believe that the total cost of compressed gas, when applied to an entire system, would exceed ½d. per lamp per hour, while the actual cost for electricity, as used on the Midland Railway, had not very greatly exceeded ¼d. per lamp per hour.

THE

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RONALDS.

The name of Ronalds takes a high position in the annals of telegraphic literature. With him may be said to have ended an era, during which period Lesarge, Grey, Lomond, Reizen, and Soemmering, prior to Ronalds, devised methods to telegraphically transmit messages. The energy of Ronalds was sufficiently damped by a wise Government, which told him that telegraphs were of no use in time of peace, and that the semaphore answered all requirements. Subsequent to Ronalds came the time of Ampère, Schilling, Gauss, Steinheil, Alexander, Davy, ending with Morse, Cooke, and Wheatstone. These later men working for the same end, but by different means, made telegraphy practical, and development was rapid and continuous. Between the forties and the fifties came the initiation of submarine telegraphy, about which Mr. Willoughby Smith has just published his reminiscences. Later still, and within the recollection of most of us, came the work of Bell and Hughes, rendering telephony practical. The historian of telegraphy might divide his history into some such periods as indicated above, and no doubt some leisured literary man will eventually undertake this work. Meanwhile we are able in this issue to give two illustrations, one of a bust of Ronalds, the other from a portrait, and trust these reproductions will be welcome to our readers. We also reproduce an autobiographical sketch of the life of Ronalds, some portions of which have previously been published, but so far as we know the whole has never before been given.

KENSINGTON AND KNIGHTSBRIDGE.

It is very often the case that those who stand outside see most of the fun, though, in the case of introducing a new departure in civilised life, only those in the thick of the fight know with what they have to contend. The meetings of electrical companies will soon be as common as those of mining companies. At present the shareholders who attend such meetings are told to "hope on." There is a good time coming, but it is not yet. Now and again we get a glimmer of light, and a 2 per cent. interim or a 5 per cent. ordinary dividend is paid, though some critics are cruel enough to say that such interim dividend is of the nature of a sop. It may be remembered that companies usually issue balance-sheets, but they do not interpret the balance-sheets, so that much is left to the imagination of the reader. We strongly object to one word in the balance-sheet of the Kensington Company, and that word is "goodwill." How much or how little of the amount carried out is due to "goodwill"? What is the value of the "goodwill" of the South Metropolitan or any other gas company, and is that value put down in the balance-sheet? We opine not. In the case of a limited liability company "goodwill" ought not to appear in the balance-sheet except under peculiar circumstances.

Having delivered our opinion on this point, which is of general interest and not special to this company alone, we may refer to the main topics discussed at the meeting. More money is required, and is to be obtained by the issue of debentures. The light has not been taken up so rapidly as was anticipated, but looking at the matter calmly, it may be assumed the anticipations were exaggerated, and progress is quite as rapid as ought to be expected. The price per unit is too high, and will have to be lowered. This is the natural outcome of progress. It is better for the company to supply 60,000 lights at 6d. than 20,000 at 8d. per unit. A few days, or rather nights, ago we were in the central station of this company, calling in quite a casual manner; and in our opinion no company has a central station more ably managed or more capable of producing all that is required of it. Every single piece of apparatus was in first-rate order, the supervision is admirable, and provision has been made to work in the most economical manner. Every detail of the work is watched with anxiety, all results tabulated, and each member of the staff thoroughly conversant with his duties.

RUMOURS RE COMPANIES.

Some time since, as most of our readers know, a large company was being prepared for the financial market to exploit electric welding. The capital of the company was to be four or five hundred thousand pounds. Various reasons caused the promoters to consider their position, and for the moment the project was withdrawn. Rumour has it that the company is soon to appear; that a hundred thousand pounds or so of its capital has been underwritten, and this time it will be put through with a flourish of trumpets. Elsewhere, however, we give certain information, which, if authentic, as we believe it to be, will once and for all put an end to preposterous claims of monopoly that have been and will be put forward to induce investors to contribute to the capital of the proposed big company. There is everything to warrant a company with a moderate capital being formed for the purpose of pushing this particular branch of electrical business—there is nothing to warrant a company with a big capital or huge payments for patents or to promoters. Our correspondent seems to think that Prof. Elihu Thomson's accidental fusing of copper wire was the origin of electric welding. It may be so for the apparatus as at present employed, but the electric current was used many years ago for the specific purpose of welding. Like many other developments, however, electric welding was not practical till the advent of the dynamo. The old experiments were made with primary batteries, and we have every cause to credit Prof. Elihu Thomson with the working out of a system of electric welding. This system has its value, but, not being a monopoly, has not the immense value the promoters of the company in this country are said to put upon it. No doubt when the prospectus is issued we shall be taunted with being misinformed. More than once we have saved the public large sums of money, and no doubt may be able to do so again. Provided the prospectus be altered in accordance with the views put forward, and a moderate amount only of loading added to the company's capital for patents and for promoters, we shall be satisfied. The business to be done in welding apparatus is not large enough to warrant over-capitalisation. Many phases of electrical work have to be developed before welding apparatus can be generally used, and when it is generally used most of it will be of a cheap and simple character, for small rather than for large work.

CORRESPONDENCE.

ACCUMULATOR INDICATORS.

SIR,—In reply to M. Roux's letter *re* accumulator indicators, my indicators were made and sold previous to May, 1890, thus anticipating M. Roux's patent by some months. Mr. Niblett also knew about them previous to the date of the patent mentioned.—Yours, etc.,

MAGNUS VOLK.

7, Eglantine-road, Wandsworth, S.W.,
May 4, 1891.

ELECTRIC WELDING.

SIR,—Few things will more clearly demonstrate the marvellous strides in electrical science than a careful perusal of the new processes of electric welding recently patented by Mr. Coffin, of Detroit, U.S. It is some few years since Prof. Elihu Thomson, of Lynn, Mass., U.S., in preparing electrical apparatus for a lecture, accidentally short-circuited an induction coil, which naturally resulted in the fusion of the copper wire of the coil. This accident was the foundation of Prof. Thomson's experiments, which resulted in the application of the electric current to the purpose of welding metals. He did not confine his experiments to copper wire, but soon found that such metals and alloys as silver, wrought iron, brass, lead, tin, zinc, aluminium, platinum, gold, etc., could not only be welded to each other, but that different metals can be welded one to another in various combinations. Three years ago, his first demonstration took place in this country, at the meeting of the British Association at Bath, and at the Glasgow Exhibition. In the autumn of 1889, its practical working was shown in London. Very many distinguished electricians, engineers, etc., witnessed the trials, and there was a consensus of opinion as to its great practical utility. Sir Frederick Bramwell superintended a series of experiments, and subsequently read a paper giving the result at a meeting at the Institute of Civil Engineers, and also at the Royal Institution. From these papers it appears some 80 welds were made in Sir F. Bramwell's presence, the metals employed being round iron of $1\frac{1}{8}$in. diameter; all the pieces were the same size. The average gross indicated horse-power is stated by Sir F Bramwell to have been 33·1; that the mean gross indicated horse-power when the engine was running light was 9·5—that is, when no current was being used. This gives as the mean gross indicated horse-power consumed in welding throughout the experiment, 23·5. The maximum indicated gross horse-power observed at any time during a weld was 50·7, the minimum 10·98.

A matter of such vast magnitude, and of such a wide range of application as that of welding almost every known metal, soon attracted the attention of other electricians, and many and varied have been the experimental trials made by them to improve on Thomson's process. It was reserved, however, for Mr. Coffin not to follow in Thomson's footsteps, but to strike out a new line. At the present time he is the inventor of over 20 patents, the majority being process patents. All these have been granted by the United States Patent Office without at any time Thomson being cited. This is the most undeniable test of their novelty and validity. Not only do these patents embrace every class of welding that has yet been done, but they accomplish some never before attempted, such as the welding of polished metal in a non-oxidising medium, by which tarnishing is prevented, welding under water, either fresh or salt, the introduction of the magnet, by which the current is not only controlled but directed; but by far the most important point in connection with Coffin's patents is that the cost of the plant is much less than Thomson's.

But what appeals more particularly to the pocket of the engineer and metal worker, and what is certain to secure its commercial success, is the great advantage over Thomson's in the working expense. Thomson requires to weld a round bar of 1¼in. diameter an average of 23·5 h.p., according to Sir F. Bramwell's report on tests made under his supervision, when the power employed was most accurately noted. Coffin is welding 1in. solid iron bar from an electrical current generated from a 1-h.p. engine.

When we bear in mind that 90 per cent. of the welding to be done in this country where electricity will be employed will be below 1in. area, the range of application for Coffin's patents must be enormous, and the cost will be within the reach of the smaller jewellers and wire workers.

Yours, etc., B.

THE ELECTRIC LIGHTING OF PUBLIC BUILDINGS: WITH SPECIAL REFERENCE TO THE ATHENÆUM ELECTRIC LIGHT INSTALLATION.*

BY PROF. JAMIESON, M.I.C.E., F.R.S.E.

(Continued from page 439.)

In such installations as we are considering, continuous-current compound-wound dynamos are preferable to shunt-wound machines for direct lighting, owing to their capability of maintaining a constant voltage within the limits of their output. The speed at which a dynamo may be driven depends upon—

1. The diameter of the armature.
2. The conditions under which it is to be worked.
3. The funds at the disposal of the engineer.

Where freedom from vibration and noise are essentials, then a moderate speed of from 350 to 600 revolutions will be found more advantageous in the long run than higher speeds, since there will be less wear and tear, and the attention required will be reduced very considerably in consequence.

By lighting the lamps direct from the dynamos, a higher efficiency is obtained at less prime cost than by the intervention of storage batteries. These are of great service, however, where a special circuit is required when the machines are at rest. It is not advisable to charge accumulators by compound-wound machines, since they are liable to have their polarity reversed by the back E.M.F. of the batteries, unless the attendant is most watchful to keep the charging voltage above that of the cells. It is, therefore, a matter for early consideration what value is to be placed on the storage cells as a means of lighting. If great reliance is to be placed upon the storage cells and their output is to be heavy, then it may be preferable to adopt shunt-wound machines with high-resistance field magnet coils having a variable external resistance in series with them. This plan enables the required potential difference at the dynamo's terminals to be maintained, either for charging or for lighting direct, without varying the speed. Or, the cells may be divided into two equal parts with resistances in circuit, and charged directly from the mains, as is done in the Liverpool central stations.

Should the accumulators be of comparatively little importance, then the series coils of one or more of the compound-wound machines may be switched out of circuit, and the dynamos run shunt-wound, when charging the cells. This is the method we adopted with two out of the four dynamos at the Athenæum. The storage cells in this case are small, consisting of only 15L E.P.S. plates, and used simply for a 25-ampere emergency circuit, including the newsroom, stairheads, etc.

Distribution of Current.

With a variable demand for current, such as is likely to occur in a public building, it is well to divide the output amongst several dynamos, so that when the demand is light one dynamo will suffice, and as the load increases the others can be switched into parallel circuit with it. It is also advisable to bring the mains supplying each floor or department to one main switchboard. This enables the engineer on duty to have more complete control over the system than the method of conveying the current from the dynamo-room by one set of main leads, and distributing it therefrom at the different landings through sectional switches and cut-outs.

Both the + and – mains from the dynamos to the switchboard, and therefrom to the different circuits, should be protected against a short circuit or excess of current by "cut outs."

An ammeter for each dynamo, and one for the charging and discharging accumulator circuit, as well as a voltmeter for direct lighting and another for the storage cells, are required in any fully-equipped installation, so as to enable the attendant to note and to regulate with ease the varying demand for current and voltage.

The complete arrangement for the distribution of current, as carried out in the Athenæum by Messrs. J. H. Holmes and Co., gives entire satisfaction.

Sir William Thomson's simple, accurate, and very handy multicellular voltmeter indicates the electrical pressure in volts of any one or other of the four dynamos at pleasure, by switching it on to their respective terminals. It does not absorb any power, for no current passes through the instrument, since its action is electrostatic, and, further, it requires no temperature coefficient. Major Cardew's platinum-wire voltmeter is held in reserve for switching into any of the circuits should the other instrument from any cause be disabled, and is further used for indicating the pressure when charging and discharging the storage cells.

Messrs. Smythe and Payne's novel "cut-offs," which are used in the main leads, have proved themselves to be most reliable in the event of a short circuit taking place. They depend for their action simply on the charring of a piece of fine gut-string, and not on the fusing of any part of the circuit, such as a lead, tin, or copper wire. They therefore come into action before the conductors can have attained a dangerously high temperature.

General Arrangement of Plant.

To enable the daily work to be carried out with a minimum of labour and a maximum of cleanliness, it is advisable to have the coal bunkers so situated that the carts can tip their contents directly into the space allotted for them, and that the bunker should be so conveniently situated with respect to the furnaces that no second handling of the fuel is necessary, except the mere shovelling of same direct from the bunkers into the fires.

Further, that the arrangement for the disposal of the ashes and other refuse should be such as to create as little dust as possible.

In installations of moderate dimensions, such as we are considering, where space is of great moment, the engines, boilers, dynamos, etc., may be all placed with advantage in one room. We know that this is contrary to the general opinion of electrical engineers, but we hold that the necessity for keeping everything tidy and in good order will thus be emphasised, and, moreover, the engineer in charge has everything directly under his observation from any part of the engine-room. Each Sentinel engine is coupled direct to two Castle dynamos (one on each side) and placed on one large sole-plate. These are thus two complete duplicate sets of generators which may be run together or separately at pleasure.

Cost of Running Plant.

In public buildings where heating and cooking are effected

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* From the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland.

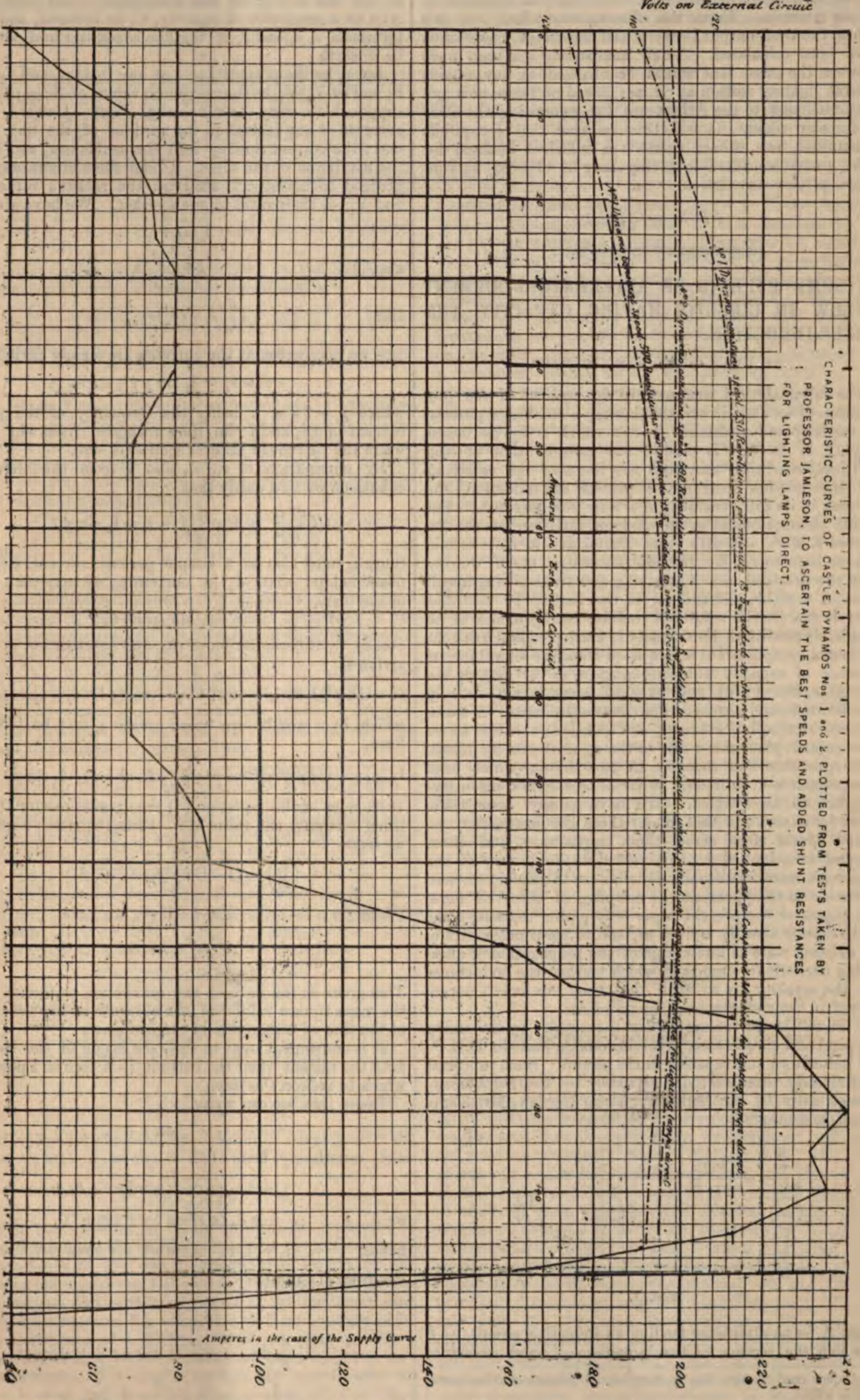

Fig. 1.—Curve of Electric Lighting Supply, March 11th, 1891.

Total Number of Watt-hours = 192,395 on March 11th, 1891.
Board of Trade Units = 192·395 " "

Cost at 8d. per Unit if supplied by Contract, £6. 6s. 7d.
Actual Cost to the Athenæum, £3. 5s. 0d.

as well as electric lighting, then, during the hours of charging cells and lighting, steam may with advantage be taken from the main boilers for these purposes, thus minimising labour and trouble. In the Athenæum, not unfrequently on a cold day, and with a heavy demand on the kitchen, upwards of 1,000lb. of steam per hour are required for these purposes.

Supply curves given, Fig. 1, show the demand for current, during an average winter's day, when fog was conspicuous by its absence. From the observations taken and this figure, the total output in watts and Board of Trade units have been calculated. A fair comparison has been made between the price that would be charged by any outside central lighting station at 8d. per Board of Trade unit and the actual cost to the Athenæum for generating the same by its own plant. It will thus be seen that for public institutions, etc., where there is a sufficient demand for light, a very considerable saving may be effected by running a private installation.

(To be continued.)

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING, MEMBER.

The full analytical treatment of the problem of the propagation of an electric current through a conductor possessing capacity and resistance is one which is by no means simple. If to this is added the consideration of the additional condition that both the line and the receiving and transmitting instruments possess self-induction, the problem in its full generality is a very complex one. For certain assumptions as to the mode of variation of the impressed E.M.F., and with other limitations, it may be said to have been solved for periodic currents; but if we consider the practical case of receiving and transmitting appliances of variable inductance, it can hardly be said that analysis enables the results of definite arrangements to be completely predicted. Fortunately in much practical work the additional complications which arise from the simultaneous presence of capacity and self-induction in the system are negligible, but useful, and existing work is not entirely thus limited; and electrical distribution by means of transformers, alternating currents, and concentric cables forces us to regard phenomena due to the co-existence of inductance resistance and capacity in one circuit, which need interpretation, even if only so far as to enable constructive mistakes to be avoided. We have already been made aware by experience that under these circumstances unexpected effects often make their appearance, and these demand examination at this period in the history of the large-scale manufacture and distribution of electric current, to enable us to appreciate the meaning of observed facts. The object of the present paper is to gather together some of the results already arrived at, and to point out a part of the existing state of knowledge of the propagation of alternating currents in circuits in which neither the inductance nor the capacity are so small that they can be left unconsidered in their effects.

2. It will be convenient to start the enquiry by examining a typical and simple case, involving simple periodic E.M.F., and inductance and capacity in the circuit. Such problems have already been treated analytically by Dr. Hopkinson; geometrically by Mr. Blakesley, Major Cardew, Mr. Kapp, myself, and others.†

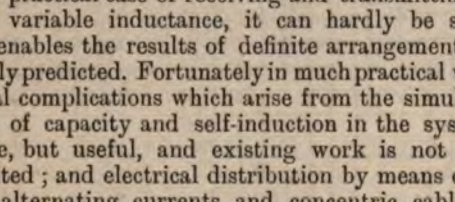

FIG. 1.

Let A be an alternator feeding an inductive circuit, *a b f*, of which the section *a b* has inductance L and resistance R, and the section *b f* has inductance *l* and resistance *r*. At *b* let a condenser of capacity, C, be inserted, and let the terminals, *e*, *d*, and *f*, of the line condenser and alternator be to earth.

Let v_0 be the potential at *a* at any instant, and v_1 that at *b*; and let V_0, V_1, be the maximum values of these potentials, supposed to vary harmonically. Let i_1 and i_2 be the currents at any instant in the sections of the line *a b*, *b f*, and *i* the current flowing into the condenser, and I_1, I_2, I, the maximum of the same. Under these circumstances we proceed to investigate what are the relative value of V_0 and V_1, or their ratio to one another. We have always

$$i_1 = i + i_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

also,

$$i = \mathrm{C}\frac{dv_1}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and

$$l\frac{d\,i_2}{dt} + r\,i_2 = v_1 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

but we may write, as the currents are simply periodic,

$$i_1 = \mathrm{I}_1 \sin p\,t \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where $p = 2\pi n$, *n* being the frequency of the periodic current in *a b*, and *t* the time reckoned from the instant when the current in its first section is zero.

By elimination of v_1, i_1, and *i* from the above four equations we find easily that

$$\mathrm{C}l\frac{d^2\,i_2}{d\,t^2} + \mathrm{C}\,r\frac{d\,i_2}{dt} + i_2 = \mathrm{I}_1 \sin p\,t \quad . \quad . \quad (5)$$

Since i_2 must also be a simple periodic current, lagging in phase behind that of the current i_1, we may take i_2 to be of the form,

$$i_2 = \mathrm{I}_2 \sin\,(p\,t - \theta) \quad . \quad . \quad . \quad . \quad (6)$$

Hence, by differentiation of (6), and substitution in (5), we arrive at

$$(1 - \mathrm{CL}\,p^2)\mathrm{I}_2\sin(pt-\theta) + \mathrm{C}rp^2\mathrm{I}_2\cos(pt-\theta) = \mathrm{I}_1\sin pt \quad (7)$$

which, by a well-known transformation, may be put in the form,

$$\mathrm{I}_2\sqrt{(1-\mathrm{C}\,l\,p^2)^2 + \mathrm{C}^2r^2p^2}\,\sin\,(p\,t - \theta + \phi) = \mathrm{I}_1 \sin p\,t \quad (8)$$

Both sides of this equation (8) are expressions for the same thing—namely, the value of i_1—hence, equating coefficients, we have

$$\left(\frac{\mathrm{I}_1}{\mathrm{I}_2}\right)^2 = (1 - \mathrm{C}\,l\,p^2)^2 + \mathrm{C}^2r^2p^2 \quad . \quad . \quad . \quad . \quad (9)$$

Putting $a = 1 - \mathrm{C}\,l\,p^2$, and $b = \mathrm{C}\,r\,p$, we have

$$\left(\frac{\mathrm{I}_1}{\mathrm{I}_2}\right)^2 = a^2 + b^2 \quad . \quad . \quad . \quad . \quad . \quad (10)$$

This gives us the ratio of the maximum, or square root of the mean square values, of the currents in the two sections of the line on either side of the condenser.

It is convenient next to shift the origin of the time, and take the instant when the current i_2 is zero as a point from which to reckon the time.

Doing this, we can write,

$$i_2 = \mathrm{I}_2 \sin p\,t \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and, accordingly, from (10),

$$i_1 = \mathrm{I}_2\,\sqrt{a_2 + b_2}\,\sin\,(p\,t + \theta);$$

or

$$i_1 = \mathrm{I}_2\,(a \sin p\,t + b \cos p\,t) \quad . \quad . \quad (12)$$

hence,

$$i_1 - i_2 = \mathrm{I}_2\,(\overline{a-1}\sin p\,t + b\cos p\,t) \quad . \quad . \quad (13)$$

but from (1) and (2)

$$i_1 - i_2 = \mathrm{C}\,\frac{d\,v_1}{d\,t};$$

$$\therefore \mathrm{C}\frac{d\,v_1}{d\,t} = \mathrm{I}_2\,(\overline{a-1}\sin p\,t + b\cos p\,t):$$

or

$$v_1 = \frac{\mathrm{I}_2}{\mathrm{C}\,p}\,(b \sin p\,t + \overline{1-a}\cos p\,t) \quad . \quad . \quad (14)$$

$$\therefore \mathrm{V}_1 = \frac{\mathrm{I}_2}{\mathrm{C}p}\sqrt{\overline{a-1}^2 + b^2} = \mathrm{I}_2\,\sqrt{r_2 + p_2 l_2} \quad (15)$$

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* Paper read before the Institution of Electrical Engineers, May 7, 1891.

† Dr. Hopkinson's paper on "The Theory of Alternating Currents" is in the *Proceedings* of the Institution of Electrical Engineers (late *Journal* of the Society of Telegraph-Engineers) for 1884, vol. xiii., p. 496. Mr. Blakesley's papers are collected in his dmirable little book on "Alternating Currents."

We have next to find the value of V_0.

$$v_0 - v_1 = L\frac{d i_1}{d t} + R i_1 \quad . \quad . \quad . \quad (16)$$

and if we substitute in (16) the value of i_1 given in (12), and of v_1 given in (14), and integrate, we arrive at

$$v_0 = I_2\left\{\left(R a + \frac{b}{C p} - L p b\right)\sin p t + \left(R b + \frac{1-a}{C p} + L p a\right)\cos p t\right\};$$

but, since $\frac{b}{C p} = r$, and $\frac{1-a}{C p} = p l$, we get by proper substitution in the above equation, and by the application of the rule for harmonic maxima, the equation,

$$V_0 = \frac{I_2}{C p}\sqrt{(A^2+B^2)(a^2+b^2)+2 B b-2 A a+1}\cdot \quad (17)$$

where $A = 1 - C L p^2$; $a = 1 - C l p^2$;
$B = C R p$; $b = C r p$.

Equations (15) and (17) give us the values of the maximum or mean potentials at the generator and condenser end of the line $a\,b$. If we divide equation (17) by equation (15), we get a value for the ratio of V_0 to V_1. A little tedious process of division and substitution brings us finally to the required result, which is,

$$\frac{V_0}{V_1} = \sqrt{(A^2+B^2)+(1-C p^2)\frac{R^2+p^2 L^2}{r^2+p^2 l^2}+\frac{2 L l p^2}{r^2+p^2 l^2}+\frac{2 R r}{r^2+p^2 l^2}} \quad (18)$$

This last equation furnishes us with the required result—viz., the ratio of the maximum or mean potentials at the ends of the inductive line, $a\,b$, in terms of the coefficients of inductance, capacity, and resistance.

Given V_0, it enables us to calculate V_1, and to say whether V_1 is greater than, less than, or equal to V_0.

3. Let us examine some particular cases. Suppose $r^2+p^2 l^2 = \infty$—that is, suppose the section of the line beyond the condenser removed—then

$$\frac{V_0}{V_1} = \sqrt{A^2+B^2} = \sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2} \quad (19)$$

This reduced case was treated by Dr. Hopkinson long ago,* and he showed, as we can easily see, that it is possible for the ratio of V_0 to V_1 to be less than unity—that is, for the potential at the receiving end, or at the condenser, to be greater than the potential at the sending end.

It is very easy to state the conditions under which this is the case. In order that V_1 shall be greater than V_0, or that there may be a rise of pressure, we must have

$$\sqrt{(1-C L p^2)^2 + C^2 R^2 p^2}$$

less than unity; hence we must have

$$(1-C L p^2)^2+C^2 R^2 p^2<1,$$

or

$$1+C^2 L^2 p^4-2 C L p^2<1-C^2 R^2 p^2,$$

or

$$C<\frac{2 L}{R^2+p^2 L^2} \quad . \quad . \quad . \quad . \quad . \quad (20)$$

If L, R, and p are constant, the value of C which makes the ratio of V_1 to V_0 a maximum is

$$C = \frac{L}{R^2+p^2 L^2}.$$

Hence, if the capacity, C, of the condenser, measured in farads, is less than the quotient obtained by dividing twice the inductance of the line, L, measured in henrys, by the square of the impedance $(R^2+p^2 L^2)$, we shall, under these circumstances, find a rise in pressure at the condenser end. For example, suppose the value of n or the frequency is 67, then $p = 421$, and $p^2 = 177{,}241$. If R = 1 ohm, and L = ·1 henry, then $R^2 + p^2 L^2 = 1{,}773$, and there ought to be a rise in pressure if C is greater than 112 microfarads; or, if R = 1 ohm, and L = 100 henrys, then $R^2 + p^2 L^2 = 1{,}772{,}410{,}000$, and there ought to be a rise in pressure if C is greater than one-eighth of a microfarad. Generally speaking, the greater L, the less will be the critical value of C. For high frequencies the criterion of rise of pressure at the condenser end is

$$C < \frac{2}{L p^2}.$$

That is to say, the critical capacity is just twice that which will at the given periodicity nullify the inductance of the armature circuit. It is worth while to note that even if the criterion for rise of pressure at the condenser end is fulfilled by L, R, C, and p, yet, as seen from equation (18), a sufficiently small impedance ($\sqrt{r^2 + p^2 l^2}$) in the shunt may nullify the effect and force V_1 to be less than V_0.

4. These condenser effects, as they may be called, are very strikingly shown when currents of high frequency are used. Quite recently, Mr. Nikola Tesla has published some interesting observations and experiments on alternating currents with the very high frequencies of 10,000 to 20,000 alternations per second, and amongst these he has described an experiment with a condenser joined across the poles of such an alternator. A machine was used giving about 20,000 alternations per second. Two bare wires about 20ft. in length were attached to the poles, and their ends connected to the terminals of a condenser. The difference of potential between parallel points on these wires was explored by a voltmeter, and it was found that the potential difference of parallel points on the wires steadily rose inch by inch from 65 volts at the terminals of the alternator to 120 volts at the terminals of the condenser; and the writer states that observations on the self-induction of the armature in its position of maximum and minimum inductance showed that the capacity which gave the greatest rise at the condenser end corresponded apparently to that which would about nullify the mean self-induction calculated from the observed maximum and minimum. This entirely corresponds to the above theoretical deduction.

5. The fact that when a condenser is thus charged by an alternating-current machine its terminal potential difference may be very much greater than that of the machine terminals, appears to have been noticed experimentally prior to the time when the simplest case was mathematically treated by Dr. Hopkinson. In the paper of the latter above referred to it is mentioned that Dr. Muirhead had observed it experimentally. In the discussion which followed Dr. Hopkinson's paper Mr. Blakesley dealt with the same matter in some geometrical diagrams, and Prof. Ayrton mentioned that in 1878 or 1879 Mr. Munro took out a patent for the use of condensers in combination with an alternate-current machine. In any case, the experimental verification of a rise of pressure along the line leading from the machine to the condenser is complete.

(To be continued.)

ELECTRIC LIGHTING IN BOMBAY.

The proposal for the experimental introduction of electric lighting in a certain area of the city of Bombay has been modified at the instance of the municipal commissioner. A smaller area than that originally contemplated will suffice for practical purposes. Messrs. Volkart Bros., who are the representatives in India of Messrs. Ganz and Co., of Buda Pesth, are to be invited to send in proposals for the lighting of the road from the Crawford Markets to the Victoria Station, and thence to the Frere Fountain, or so much of that area as the money in hand—rather less than 60,000 rupees—may justify. The tenders asked for on previous occasions were to cover the lighting of the Crawford Markets, Hornby-row and the Esplanade-road, Rampart-row and the Crescent, the Wellington Fountain, the Apollo Bunder-road and Pier, Church Gate-street, and the Elphinstone Circle. This was a sufficiently large experiment, one might have supposed, to interest speculative electricians, but advertisements in England and the United States brought only three tenders—one apiece from three continents. This lack of enterprise was, no doubt mainly due to the conditions laid down, by which competitors were to bind themselves to provide all the plant necessary, and make the experiment at their own risk for a period of two years certain. At the expiration of two years there was nothing to bind the Corporation to go on with the experiment, whether successful or not, or to purchase the plant. Mr. Acworth does not overstate the case when he says, in his report to the Standing Committee, that the terms offered were not attractive. Some of the largest firms declined to even consider the proposal, on the ground that the risk and the cost would not be counterbalanced by any fair prospect of equivalent return. Nevertheless, three eminent firms entered the lists. Messrs. L. Fabro and Co. agreed to light up the localities specified for a sum of 1 lakh and 20,000 rupees for one year, or 2 lakhs, 38,000 rupees for two years. Seeing that the municipal vote for the experiment was restricted to a frugal 30,000 rupees per annum, Messrs. L. Fabro and Co. were scarcely within a measurable distance of success. Messrs. Ganz and Co. were more moderate, asking 90,000 rupees for one year, or 1 lakh 80,000 rupees for two years. Messrs. Edison, Swan, and Co. went outside the terms of the specification, and offered to sell plant to the Corporation for £10,000, undertaking to run and maintain the same for £1,100 a year, provided the Municipality supplied coal and water. Under these circumstances, the municipal commissioner came to the conclusion that it is useless to ask firms to lay down expensive plant with no security that it will be purchased, or the contract renewed after the lapse of two years. He proposed two alternatives—that the Municipality should purchase its own plant at a cost of 2½ lakhs or that they should contract with Messrs. Ganz, or some other well-known firm, to light a small area experimentally for a year or two. The objection to the first proposal is the obvious one that the municipal officers have no experience of electric lighting, and that a special staff would have to be imported; and all the risks attending the initiation of a new enterprise would have to be faced. The second alternative has been approved by the Standing Committee. It is perhaps still possible to profit by the result of the experience acquired and to eliminate from the new proposal that which constituted the chief element of failure in the tentatives hitherto made. Why not call for estimates for lighting the restricted area now chosen for a period of, say, five years, so that the firm undertaking the work will have some inducement to make full and adequate provision for the success of the experiment? A further proviso that in the event of the experiment proving satisfactory, the period would be prolonged for a further period of two or three years, would stimulate enterprise.—*Bombay Paper.*

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* See *Proceedings* of the Institution of Electrical Engineers for 1884, page 513.

LONDON COUNTY COUNCIL.

NEW SUBWAY REGULATIONS, ETC.

At the meeting of the Council on Tuesday the report of the Highways Committee was brought up, and contained the following clauses referring to electrical matters:

Electric Lighting Provisional Orders, 1891.—We have considered a letter from the Board of Trade stating, with reference to the Southwark Electric Lighting Order, that most of the amendments suggested by us on behalf of the Council have been adopted; but there are one or two of those not adopted by the Board which in our opinion should be further pressed. We suggested the omission of the power of transferring the powers under the order to a company supplying an area within the City of London, as the provisions in the City orders relative to the Council differ from those for areas outside, and some difficulty might arise in the event of amalgamation of the two undertakings. The Board does not consider this omission necessary; and, this being so, we have suggested that special provision should be made for keeping the accounts separate, and for ensuring that the Council's powers under the Southwark order shall not be diminished by amalgamation. There are two or three other minor amendments which appear to be required, and we have accordingly directed that the Board should be asked to consider those also. We recommend:

> That our action with reference to the Southwark Electric Lighting Order be approved.

Subways—Regulations for the Use of.—We reported on the 28th of April that we were preparing, and hoped soon to submit to the Council, regulations applicable to all the Council's subways. These regulations, which have been very carefully considered by us, are supplementary to the by-laws already made by the Council ler the Subways Act, 1868, and confirmed by the Board of de and the Home Secretary, and are intended to apply not only to the subways referred in that Act, but to all others under the control of the Council. We recommend—

> That the Council do make regulations in the following form—
>
> The London County Council, hereinafter referred to as the Council, doth hereby make the following regulations, terms, and conditions, to be observed by any company, body, or person using a subway. Throughout these regulations the word pipe includes gas-pipe, water-pipe, wire, main, line, tube for wires or other tube and any apparatus connected therewith.
>
> 1. Fourteen days at the least before the date at which any company, body, or person proposes to lay a new pipe or to alter any existing pipe in a subway, notice shall be given to the Council by such company, body, or person of the size, number, length, purpose, material, and proposed connections of such new pipe, or of the proposed alterations, with particulars of supports and other works connected therewith, and plans and sections with details of the mode of fixing the same, and in the case of electric lines, the method of insulation.
>
> 2. Whenever the company, body, or person having a pipe in a subway desires to enter such subway, they or he shall give to the chief engineer of the Council at least 24 hours' notice of such desire, and shall not (except in case of emergency) enter therein without the written consent of such engineer.
>
> 3. The keys of the subway entrances shall be kept at such places, and by such officials, as may from time to time be appointed by the Council for the purpose; each company, body, and person having pipes in the subway shall be supplied by the Council with a card stating the places at which, and the names of the officials in whose custody, the keys are kept, which card shall be produced to the official whenever application is made for access to a subway; and such officials shall arrange for the opening and closing, when required, of the gratings or covers for persons entering or leaving the subways, but it shall be the duty of the company, body, or person using a subway to provide a watchman for each grating or cover which is left open, and to temporarily fence or guard the opening.
>
> 4. The position of a pipe in a subway shall be subject to the approval of the engineer of the Council, and if required the pipe must be supported independently of any other.
>
> 5. Except in cases of emergency, a subway will only be opened between the hours of 6 a.m. and 5 p.m.
>
> 6. Each pipe placed in a subway shall, under the supervision of the Council's chief engineer, be maintained by the company, body, or person to whom it belongs, and any damage done by such company, body, or person, or caused by, or by means of their or his pipes or pipe, to a subway or to any pipe therein shall be made good by them or him respectively; and in the event of a pipe or subway not being so maintained or made good, the Council may have the necessary work executed at the expense of such company, body, or person, and the Council will not hold itself responsible for any accident caused by the act or default of any agent or servant of the company, body, or person using the subway.

Should the above regulations be adopted by the Council, it will be necessary for the Council, in order to give proper and efficient facilities of access to companies and others using the subways, to appoint an additional subway inspector and an assistant inspector. The wages paid to the persons at present employed in these capacities are 35s. and 26s. a week respectively, and we recommend—

> That an additional subway inspector at the wages of 35s. a week, and an additional assistant inspector at the wages of 26s. a week, be appointed, and that it be referred to the Highways Committee to select two persons suitable for the appointments.

Under the Subways Act of 1868, the Council has no power to charge a rent to gas, water, and other companies using the subways specified in the Act, but is empowered to make a charge for supervision. Under the Electric Lighting Orders and Acts, however, the Council has power to require the electric lighting companies to lay their mains in the subways, and to charge a rent for the use of the subways, which rent must be agreed upon, or in case of difference, settled by an arbitrator to be appointed by the Board of Trade. We have prepared the following scales of charges in respect of each of these matters, and we recommend—

> That the following scales of charges be approved by the Council with reference to the use of the Council's subways; and that the clerk be instructed to send copies of them to the companies and others concerned with an intimation that the Council will be prepared to consider any representations which they may wish to make with reference thereto (Table A).

Charges according to Table A shall be payable by the company, body, or person using a subway.

These charges are for the use of the entire length of the subways. Proportionate charges will be made for shorter lengths.

In addition to the above the charge for supervision for each day or part of a day during which a pipe is being laid or renewed shall be 5s. The charge for opening or closing a subway, at any time other than that fixed for the daily visit of the Council's inspector, shall be 1s.

In cases where the Council is authorised to charge a rent for the use of any subway, it is willing to accept payments on the following scale (Table B) from any company, body, or person using a subway; and any company, body, or person using any such subway without making any other agreement shall be deemed to agree to payment for such use upon the said scale.

TABLE A.—Scale of annual charges for supervision to companies and others using the subways.

Name of subway.	Length in yards, about.	CHARGE IN RESPECT OF A PIPE. (A pipe includes a gas-pipe, water-pipe, main, *line tube for wires*, or other tube.) Internal diameter of pipes.					
		Under 3in.	Over 3in. and under 6in.	6in. to 18in.	18in. to 24in.	24in. to 36in.	Above 36in.
		£	£	£	£	£	£
Garrick-street...............	130	1	1	1	1	2	3
Commercial-road East ...	380	1	1	1	2	5	8
Northumberland-avenue.	310	1	1	1	2	5	8
Southwark-street	900	1	1	3	6	11	19
Shaftesbury-avenue	900	1	1	3	6	11	19
Charing Cross-road	900	1	1	3	6	11	19
Queen Victoria-street ...	1,200	1	2	4	8	15	25
Victoria-embankment ...	2,230	1	3	7	14	28	46

TABLE B.—Scale of annual rent to be charged by the Council under the Electric Lighting Orders and Acts, 1889, for the use of a subway by electric lighting companies.

Name of subway.	Length in yards, about.	CHARGE IN RESPECT OF A PIPE. (A pipe includes a wire, main, *line*, *tube for wires*, or other tube.) Internal diameter of pipes.			
		3in. and under.	Over 3in. and under 6in.	6in. to 12in.	12in. to 18in.
		£. s. d.	£. s. d.	£. s. d.	£. s. d.
Garrick-street	130	2 0 0	3 10 0	4 0 0	5 0 0
Commercial-road East	380	5 0 0	9 10 0	11 0 0	14 0 0
Northumberland-avenue	310	4 0 0	8 0 0	9 10 0	12 0 0
Southwark-street	900	12 0 0	22 10 0	26 0 0	34 0 0
Shaftesbury-avenue	900	12 0 0	22 10 0	26 0 0	34 0 0
Charing Cross-road.........................	900	12 0 0	22 10 0	26 0 0	34 0 0
Queen Victoria-street	1,200	15 0 0	30 0 0	35 0 0	45 0 0
Victoria-embankment	2,230	30 0 0	56 0 0	65 0 0	84 0 0

These charges are for the use of the entire length of a subway. Proportionate charges will be made for shorter lengths.

In addition to the above, the charge for supervision for each day or part of a day during which a pipe is being laid or renewed shall be 5s. The charge for opening or closing any subway, at any time other than that fixed for the daily visit of the Council's inspector shall be 1s.

Notices under Electric Lighting Orders and Acts.—We have considered a notice (registered No. 198) dated 24th April, 1891, from the Kensington and Knightsbridge Electric Lighting Company, of proposed extension of mains in Sussex-villas (one plan, No. 189A). There is no objection to these works; and we recommend—

> That the sanction of the Council be given to the works referred to in the notice (registered No. 198) dated 24th April, 1891, of the Kensington and Knightsbridge Electric Lighting Company.

The House-to-House Electric Light Supply Company has also given a notice (registered No. 199) dated 25th April, 1891, of a proposed extension of mains in Lexham-gardens (one plan). The proposed works are unobjectionable; and we recommend—

> That the sanction of the Council be given to the works referred to in the notice (registered No. 199), dated 25th April, 1891, of the House-to-House Electric Light Supply Company, upon condition that the company do give two days' notice to Council's chief engineer before commencing the work; that no pipes of a larger diameter than 6in. shall be used; that the mains shall be laid under the footways wherever it is found practicable to do so; that the street boxes to be used shall be of the pattern approved by the Council; and that as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, each insulated from the other as far as practicable, and that the outer cover shall be efficiently connected with earth.

We have also to report the receipt of the undermentioned notices given by the Electricity Supply Corporation, in accordance with the resolution of the Council to accept four days' (instead of one month's) notice in respect of the laying of service lines from mains already laid—

27th April, 1891—To 447, Strand.
28th ,, —To 6, Grand Hotel-building

LEGAL INTELLIGENCE.

IN RE THE ELECTRICAL ENGINEERING CORPORATION, LIMITED.

Upon the hearing of this petition before Mr. Justice Kekewich on Saturday, which was presented by creditors, for the winding up of the above-named company, a question of importance and interest arose in reference to the effect of the new procedure introduced by the Companies Winding-up Act, 1890—namely, how far the Court, in the exercise of its discretion, will have regard to the existence of that procedure in considering whether a supervision order or a compulsory order should be made. The petitioners were the holders for value of a bill of exchange which had been accepted by the company, and subsequently dishonoured at maturity. Previously to the presentation of the petition an order was made in a debenture holder's action for the appointment of a receiver and manager of the company's undertaking and property. It was stated that the debentures comprised the whole of the assets of the company, including the uncalled capital. After the presentation of the petition, the company passed resolutions for a voluntary winding up.

Mr. Marten, Q.C., and **Mr. O. L. Clare**, for the petitioners, asked for a compulsory order.

Mr. Swinfen Eady and Mr. Le Fanu appeared for the company.

Mr. Justice Kekewich said that he was not sure he ought to feel reluctance in doing that which he thought it right to do, and yet he confessed he was reluctant to refuse the petitioners the order which they asked. The petitioners were the holders of a bill of exchange accepted by a mercantile firm, and not only were they told that they could not now have the only remedy which the law gave them, but they were deprived of that remedy because the mercantile firm, since the proceedings were commenced, had determined to wind up their own affairs in their own way. In the case as so stated there was no doubt some little hardship and some inconsistency with what were by many regarded as common law rights. This company, which his lordship had referred to as a mercantile firm, had managed to get, somehow or other, £50,000, or, at all events, that was the amount of their capital supposed to be represented by cash. That was apparently all gone. Certainly there was none of it left to answer the petitioners' claim, and the company had borrowed £20,000 on debentures, and were indebted to their creditors to an amount which the petitioners said was £20,000, and which the company stated to be £12,000. The case therefore appeared to be one which deserved investigation by the Official Receiver, who under the new legislation looked into such cases, and, as his lordship was glad to observe, showed no reluctance to do his duty. But the Court of Appeal, in the case of *In re* the New York Exchange, Limited (Law Reports, 39 Ch. D., 415), had held that a resolution to wind up voluntarily might be passed after the presentation of the petition, so as to put a creditor who asked for a compulsory order to the necessity of proving that he would be prejudiced by the voluntary winding up; and the Court of Appeal further held, affirming the judgment of the present Lord Justice Kay (then Mr. Justice Kay), that, under circumstances similar to those which existed in the present case—where it was not shown that there had been any misapplication of moneys between the date from which a compulsory order would take effect and that when the voluntary winding up commenced—the creditor was not prejudiced by a supervision order being made. In that case Mr. Justice Kay said that he wished to prevent costs which were not positively necessary, and pointed out that if a supervision order were made any person aggrieved might apply to the Court in reference to the winding up. That view found favour with the Court of Appeal, and was applicable to the present case. No doubt a petitioner so endeavouring to interfere with the voluntary winding up was in a position of considerable difficulty, and had to act at a risk, which was a real one, as to costs; but still he had that remedy. To what extent would the petitioners be injured? An important circumstance to be regarded was this—that, as was admitted, the debentures covered everything belonging to the company, even (according to the modern form of debenture) the uncalled capital. There must, so far as could be seen, be some uncalled capital which would go to the debenture holders; but apparently there would be absolutely nothing coming to the petitioners. The only advantage, therefore, of a compulsory order would be that which would be gained by the public if these matters were investigated. Great as that advantage to the public might be, his lordship could not regard it as such an advantage to the petitioners that by not having it they would be prejudiced within the meaning of section 145 of the Companies Act, 1862. On that ground a supervision order must now be made.—*The Times.*

THE ANGLO-AMERICAN TELEGRAPH COMPANY AND THE PARIS AND NEW YORK TELEGRAPH COMPANY.

The following is an account of the action between these companies, which was argued before the French Council of State in Paris on Friday, the 1st inst.

The Council of State in Paris was occupied on Friday last with hearing the appeal of the Anglo-American Company from the adverse decision of the Council of Prefecture of the Seine on March 19, 1889, in the action of that company against the Paris and New York Telegraph (P.Q.) Company.

This action was first commenced in the Tribunal of Commerce of Paris early in 1887 for specific performance by the Paris and New York Company of the joint purse agreements made by them in 1880 and 1882 with the Anglo-American, the Direct United States Cable, and the Western Union Companies, or, in the alternative, for damages for breach of those agreements.

After the agreement of 1880 had been in operation for six years, greatly to the advantage of the Paris and New York Company, the Mackay-Bennett Combination (Commercial Cable Company) appeared to have obtained a preponderating influence on the French company, and on Dec. 31, 1886, the managing director of that company abruptly gave notice to the Anglo-American and other companies, parties to the agreements, that, in pursuance of a letter of the previous day from M. Granet, then Minister of Posts and Telegraphs, the Paris and New York Company put an end to the joint purse agreements as being contrary to the terms of their concession from the French Government, which required the written consent of the Government to any such agreement, and which consent the Government had not given.

Count Dillon was then managing director of the Commercial Cable Company, and had previously held the same position in the Paris and New York Company, and it was alleged that the Minister's letter had been written at the instigation of one of those companies. It is certain that the French company took no step to modify the Minister's requisition, or to obtain from him the written consent which was said to be necessary, and that on January 27, 1887, they made an agreement with the Commercial Cable Company.

On January 9, 1888, the Tribunal of Commerce gave judgment in the action in favour of the Anglo-American Company, requiring the Paris and New York Company to resume performance of the agreements, and awarding the Anglo Company heavy damages.

The Paris and New York Company appealed to the Court of Appeal, and there for the first time objected to the jurisdiction of the Tribunal of Commerce, on the ground that as the question arose under a Government concession, the interpretation of that concession and of the Minister's letter belonged to the administrative tribunals (the Council of the Prefecture of the Seine, with appeal to the Council of State). The Court of Appeal so far agreed in this view as to direct that the questions on the meaning and effect of the concession and of the Ministerial letter should be referred to the administrative tribunals, and reserved its own decision on the other matters in issue.

On March 19th, 1889, the Council of the Prefecture decided in favour of the Paris and New York Company's contentions. From this decision the Anglo-American Company appealed to the Council of State. The case was argued at length on Friday, and the legal commissary of the Government having given his opinion on several grounds against the Paris and New York Company, the President of the Council, at 10 o'clock on the same night, pronounced judgment in favour of the Anglo-American Company, basing the decision of the Council on the ground that the Ministerial letter of December 30, 1886, was not an order to denounce or annul the agreements, but simply a notice to the Paris and New York Company to observe the conditions of their concession, and that this letter was no obstacle to their taking the necessary steps to obtain the express written consent of the Government to the agreements. The defendants were condemned to pay the costs.

This important judgment, although final on the main legal point, is not an end of the litigation. The case will now go back to the Court of Appeal to deal with the other matters, including the amount of damages to be paid by the defendants, which, at the date of the judgment of the Tribunal of Commerce, amounted to about £32,000.

The damages payable after the notification of the first judgment were reserved by the Tribunal of Commerce for further consideration, and will now have to be fixed.

With respect to the written consent of the Government not having been originally obtained, it is explained that in October, 1880, the late M. Pouyer-Quertier applied to M. Cochery, then Minister of Posts and Telegraphs, for his consent to the first agreement, and was informed by M. Cochery that the agreement, not being for an amalgamation or lease of the lines, did not require the consent of the Government. In consequence of this statement the agreement was put in force and acted upon for six years, with the results above stated.—*The Times.*

COMPANIES' MEETINGS.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY.

Directors: Alfred Sohier Bolton, Esq.; Sir Frederick J. Bramwell, Bart, F.R.S.; G. H. Hopkinson, Esq.; Granville R. Ryder, Esq.; R. W. Wallace, Esq.

Report of the Directors presented at the fourth ordinary general meeting, held at 1, Great George-street, Westminster, on Monday, at 5 p.m.

The Directors beg to submit to the shareholders a statement of the accounts of the Company, together with a report of the position of the undertaking at the end of the year 1890. The whole of the compulsory area has had its streets, with the exception of about three-quarters of a mile, supplied with mains, and in 2½ miles of streets, external to this area, mains have also been provided, making the total length of streets down which mains have been placed 10 miles, about four miles of which have been executed in the year 1890. It is computed that there are about 1,300 houses fronting on these mains, and on December 31 last only 291 were taking current. During the year the number of houses and shops connected with the system has increased from 147 on December 31, 1889, to 291 on December 31, 1890; while the number of lamps calculated on the usual basis of 8 c.p. has increased from 11,794 to 25,535. The battery station in Queen's-terrace-mews, which was in the course of construction at the time of the last report, has now been completed and at work for some months with most satisfactory results. The plant at both Kensington-court and Chapel-place stations has been increased, not only to meet the extra lighting obtained during the year, but also to provide power for a large increase of demand. It may be found, however, that the demand will increase with sufficient rapidity to necessitate the execution during the current year of larger extensions than the Company's present funds would enable them to provide. To guard against such a contingency the Directors think it would be well that they should be in a position to issue some further preference shares, those of the first issue having been already taken up, with the exception of about £2,000. They will, therefore, submit to the shareholders the requisite resolution for creating further preference shares, the date and conditions of their issue being left to be determined by the Directors when the money is wanted. The dividend on the 6 per cent. preference shares was duly paid to the 30th June, 1890, and out of the balance standing to the credit of the net revenue account on the 31st December, 1890—£1,804. 2s. 2d.—the sum of £922. 18s. 3d. has been appropriated for the payment of the preference dividend to that date, leaving £881. 3s. 11d. available for the next account. Sir Charles Grant retired from the directorship during the year, and Mr. George H. Hopkinson was appointed by the Directors to fill the vacancy. In accordance with the articles of association, Mr. Granville R. Ryder and Mr. R. W. Wallace retire from the directorship, and being eligible offer themselves for re-election. The auditors, Messrs. Lovelock, H. W. Whiffen, and Dickinson, offer themselves for re-election.

BALANCE-SHEET, 31ST DECEMBER, 1890.

Dr.		£	s.	d.
Capital, 15,000 ordinary shares of £5 each		75,000	0	0
,, 7,680 1st preference shares of £5 each = ...	£38,400			
Less calls in arrears................	1,750			
		36,650	0	0
Sundry creditors on bills payable, and open accounts		14,991	10	4
Renewal account, balance at credit thereof		1,398	14	1
Net revenue account, balance at credit thereof		1,804	2	2
		£129,844	6	7

Cr.		£	s.	d.
Plant, buildings, mains, furniture and fittings, provisional orders, and goodwill		117,828	11	6
Freehold and leasehold property	£5,307 7 1			
Less depreciation	85 14 2			
		5,221	12	11
Preliminary expenses		623	12	11
Sundry debtors		4,256	12	11
Stock in trade and stores		437	9	4
Consols		549	3	10
Cash at bankers, Messrs. Hopkinson	633 5 3			
,, ,, London and County Bank	290 2 0			
Cash in hand	3 15 11			
		927	3	2
		£129,844	6	7

REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Dr.	£	s.	d.
Manufacturing electricity, coal, oil, water, waste, wages, and sundries	2,915	8	8
Repairs to leasehold property	2	13	8
Repairs to apparatus to consumers' premises	8	19	4
Incandescent lamps	228	0	7
Salaries	723	11	6
Miscellaneous expenses, including law charges and auditor	353	19	5
Rent and taxes	731	15	6
Insurance	56	4	0
Renewal account, sundry various percentages on buildings, mains, plant, batteries	1,823	12	8
Sinking fund	85	14	2
Balance	1,404	14	8
	£8,334	14	2

Cr.		£	s.	d.
Sale of electricity	£7,865 5 2			
Less rebate	156 10 11			
		7,708	14	3
Rent of meters		265	0	1
Repairs of apparatus on consumers' premises		10	9	5
Sale and maintenance of lamps		226	15	5
Rent receivable		123	15	0
		£8,334	14	2

NET REVENUE ACCOUNT.

Dr.	£	s.	d.
Dividends at the rate of 6 per cent. per annum on preference shares, June 30th, 1890	385	6	6
Balance	1,804	2	2
	£2,189	8	8

Cr.	£	s.	d.
Balance from last account	778	6	1
Balance brought from revenue account	1,404	14	8
Interest	6	7	11
	£2,189	8	8

RENEWAL ACCOUNT.

Dr.	£	s.	d,
Maintenance of plant, buildings, mains, meters, instruments, etc.	974	2	5
Balance as per balance-sheet	1,398	14	1
	£2,372	16	6

Cr.	£	s.	d.
Balance from last account invested in consols	549	3	10
Amount brought from revenue account	1,823	12	8
	£2,372	16	6

The fourth ordinary general meeting of this Company was held at 1, Great George-street, S.W., on Monday, Mr. Granville R. Ryder in the chair.

In moving the adoption of the report and accounts, the **Chairman** said he would make a few remarks with regard to the prospects of the Company. They would observe from the report (given above) that during the year ending 31st December last they added four miles of mains to their streets, leaving practically only three miles to be done. The whole of their area included about 13 miles, of which 10 were completed. The number of houses and shops connected with their system to which they were serving light had increased from 147 on December 31 1889, to 291 last December. The number of lamps, taking them at 8 c.p. each, had increased during the same period from 11,794 to 25,535. It would probably be of interest to the shareholders to know that that rate of increase had been maintained during the present year, and that up to the 30th April last the number of houses and shops served by the Company had increased from 291 to 342, and the number of lamps from 25,535 to 30,455. That was, he thought, satisfactory progress. The form of the accounts had been altered on the advice of the Auditors, and he (the Chairman) thought the alteration an improvement. The amount carried forward at the end of the year, after paying the 6 per cent. preference shareholders, was £881. 3s. 11d. That did not agree with the amount in the balance-sheet, the reason being that the amount of interest due on 31st December last was not debited to this account. Therefore, it left them really with a balance of £831. 3s. 11d. to carry forward. They had carried to renewal fund £849. 10s. 3d., to which had to be added £549. 3s. 10d., carried forward from former account, making together £1,398. 14s. 1d. As to the prospects of the Company, they had now been working for some time on a considerably extended scale, and therefore he thought the Board could give shareholders trustworthy data upon which any estimate of future working could be based. He did not think there was any real difficulty as to customers. It was true they had not multiplied as quickly as they (the Board) could have wished; but at the same time electric lighting was the light of the future, certainly so far as the better class of houses and shops was concerned, therefore a large increase of their business was only a question of time. The point was not so much whether they would get custom, as when they got it, had they a prospect of making profits? He thought they had. Mr. Erskine, the secretary, and their staff had lately been engaged in ascertaining what the average annual cost of the light was to their consumers per lamp. This, of course, was the same thing as saying what was the gross annual income of the Company per lamp. They had gone into the figures very carefully, and found that though there was an enormous variation between houses and houses and shops and shops, there was no difficulty in arriving at the average, which came out at 10s. per lamp per annum. So that if they had 40,000 lamps, these would produce £20,000 a year. And this led him to the point—what could their present plant carry? They had come to the conclusion that it would carry about 15,000 more lamps than it did on December 31 last, or, rather, about 10,000 more than at the present time. This would bring the number up to 40,000. What net profits could they get out of the resulting income of £20,000 per annum? The data they had to go on pointed to the conclusion that they could calculate on 35 to 40 per cent. net profit, or from £7,000 to £8,000 a year. If they got this they would, in the first instance, pay £3,000 interest on the 50,000 first preference shares, and that would leave them £4,000 or £5,000 available for a dividend upon the £75,000 of ordinary share capital. He thought these data very satisfactory, because he did not consider the having 40,000 lamps a matter of the future. He had every reason to suppose that they would have arrived at that number before the end of the year. The Directors were asking shareholders for power to raise more capital, but they need be under no apprehension that the Board wanted to raise more than they could possibly help. It had always been their policy to live from hand to mouth in the matter of capital. They might also be perfectly certain that any capital they applied for would only be expended on plant, mains, etc. Mr. Erskine (the secretary) had worked out the figures as to what profit they might expect to get on £10,000 expended on plant and mains for supplying 10,000 lamps, and it ought to give them £2,000 net. Therefore going in for fresh capital would be an advantage to ordinary shareholders, as giving the Company a larger amount of profit. With regard to the form of issue, the Board asked shareholders to give them a free hand in the matter; because, by the articles of association, they were able to raise the capital by debentures or debenture stock without the sanction of the shareholders. But they would ask them (the shareholders) to allow them to raise the money by the issue of second preference shares. The outside amount of capital that would be required in the end would not exceed £175,000 to £180,000, or £55,000 more than they had at present, and that would only be required when the whole of their district had to be worked. It was not likely that they would want more than £10,000 for this year, and possibly £10,000 for next. It might be satisfactory to shareholders to know that the Secretary had worked out a balance-sheet for the first three months of this year, and that the profits for this period were sufficient to pay the preference shareholders for the first six months of the year, and carry forward a small balance.

The motion was seconded by **Mr. Hopkinson**, and carried, after some discussion.

The **Chairman** then proposed a resolution to the effect that the capital of the Company be increased by the creation of 10,000 new shares of £5 each, to be called second preference shares, to be issued at such times and in such amounts, under such conditions, and at such rate of interest as should be determined by the Directors. The second preference shareholders to have no right of voting at any meeting of the Company in respect of such shares.

This was duly seconded and carried.

Mr. Crompton thought the shareholders who had spoken had made a great mistake in thinking they were going to get a revenue out of an industrial concern like electric lighting in its earlier stages, particularly with a rival having a monopoly like gas. He thought it perfectly wonderful that they had got on as they had. The Company's business had rather hung fire during last year, and consequently the number of lamps attached at the end of 1890 was somewhat less than he had imagined it would be, but now they were going on better. He thought if shareholders would but be patient they would find their shares were a good investment. They stood in quite as good a position as gas shares when the latter were beginning to pay dividends. If they looked at the accounts and weighed the extremely moderate statements of the Chairman they must see that, unless the business was mismanaged, a dividend would certainly be paid. The only thing to prevent it would be some great accident to their machinery, to which everyone was liable. He was a holder of ordinary shares, and he was sure that if they waited they would find them a most valuable property. The Chairman had shown them that with a very small expenditure sums of £10,000 would bring in an enormous return. They had got over all their heavy expenditure, and had kept well within the original estimates. The only thing in which they had been deceived had been the rate at which the public took the light. But in other companies the rate had been kept up. Take the case of the St. James's Company. If their (the Kensington Company's) rate had been as great as the St. James's, taking the economy of working the Kensington as compared with the St. James's into consideration, they, the shareholders in the Kensington, would now be getting a good return on their ordinary shares. No doubt they would do so in a little time. He thought Mr. Hedges was right, and they would have to reduce the price per unit.

Mr. Granville Ryder and Mr. R. W. Wallace, retiring directors, were unanimously re-elected, as were the auditors, Messrs. Lovelock, H. W. Whiffen, and Dickinson.

A vote of thanks to the Chairman closed the proceedings.

ORIENTAL TELEPHONE COMPANY.

At an extraordinary general meeting of this Company on Wednesday, the resolution passed at the meeting on April 15, altering the articles so as to allow the Company to supply electrical apparatus generally, and to generate and utilise electricity and magnetism, was confirmed.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.

The half-yearly meeting of this Company was held at Winchester House on Wednesday, Sir James Anderson, chairman, presiding.

In moving the adoption of the report and accounts, the **Chairman** said he did not want to alarm the meeting, because he was not alarmed himself; but it would be wrong on his part not to foreshadow that they were on the eve of a turning point, and perhaps of a crisis, in connection with the making of opposing lines. Their partners, the Western Coast line, were duplicating their cables, and when these were duplexed as well as their own, the company would be very strong. It had been the policy of the Board, ever since the inception of that undertaking 18 years ago, to have a large reserve fund, and, fortunately, some time ago that fund reached a point which enabled them to duplicate their whole system without adding to their capital, except by a small debenture debt which was passing away. Besides that, they had in the bank and in securities upwards of £400,000 as a substantial addition to the growing reserve. The owners of the competing lines could, when they were laid, have no other policy than that of reducing tariffs; but, having their own lines duplexed, they would be quite in a position to meet them whenever they liked to try any experiment of that kind. They would come down as well as their competitors. So far as his calculations went, taking the worst view of the effect of those lines on their tariff, they need not despair of getting a fair dividend and adding to the reserve. With a large reserve of carrying power, and a large reserve of cash, they had the means of extending their system through chinks in the armour of their opponents in a manner which would render themselves almost invulnerable. They could not hope to keep a monopoly for ever, but he thought they had as good a chance of continuing the existing rates of profit as any other company. In referring to the accounts, he remarked that there was an increase of £22,244 in the receipts, of 16,000 in the number of messages, and of £1,093 in the expenses. The motion was carried, and a dividend and bonus at the rate of 8 per cent. for the half-year declared.

SUBMARINE CABLES TRUST.

The twentieth ordinary annual meeting of the certificate holders of this trust was held on Tuesday at Winchester House, Sir John Pender presiding.

The **Chairman**, in moving the adoption of the report, said the revenue for the past year had amounted to £23,666, as against £23,094 in 1890, showing an increase of £572. Of this increase £264 arose from a small profit made by the Trustees on a temporary investment of their funds, and the remainder from an improvement in the dividend received on their investment in Anglo-American stock. The expenses for the year amounted to £1,175, as compared with £1,274 in 1890, showing a saving of £99. They were, therefore, working at the rate of £205 per annum less than formerly, the economy shown being mainly due to their not having filled up the vacancy on the Board caused by the death of Sir Daniel Gooch. The accounts showed that they were now earning 6¾ per cent. on the amount of their outstanding certificates. Their coupons, as the holders knew, were six months in arrear, and while they were in this position the certificate holders would receive, in addition to the usual 6 per cent., as much as possible in reduction of the overdue coupons. They proposed, therefore, paying £1 on the 15th inst., and the balance of £2 as soon as they had sufficient money for the purpose.

The motion was seconded by the **Marquis of Tweedale**, and carried.

COMPANIES' REPORTS.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

The Directors, in their half-yearly report, recommend dividends of 6s. per share on the first and second preference shares and 9d. per share on the ordinary shares, together with a payment of 28s. 6d. per share on the second preference shares, being balance of arrears of dividend to June 30 last, leaving £668 to be carried forward. The negotiations for the laying of a new cable between Demerara and Trinidad have been concluded, British Guiana agreeing to pay the Company an annual subsidy of £4,500 for a period of 10 years. To provide the necessary funds for laying the new cable the Directors propose to issue £50,000 of debentures.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

The report of the Directors for the half-year ended December 31 says the total earnings amount to £108,817. 10s. 5d., as against £86,403. 0s. 7d., showing an increase of £22,414. 9s. 10d., compared with the half-year to December 31, 1889. The working expenses amount to £37,200. 2s. 4d., as against £40,391. 11s. 9d., a decrease of £3,191. 9s. 5d. Including the amount brought forward from June 30, 1890 (£5,751. 7s.), and the dividend received upon the shares held in the Platino Company, the balance to the credit of the revenue account is £86,602. 5s. 1d., from which has been deducted £13,164 for debenture interest and £5,936 for the debenture redemption fund, leaving £67,502. 5s. 1d., of which £20,000 has been placed to the reserve fund. The Directors now recommend the payment of a dividend of 9s. per share on the ordinary shares for the half-year, making, with the dividend paid in November last, £5 per cent. for the year, leaving a balance of £6,070. 6s. 1d. to be carried forward. In the case of shares which have been divided into preferred and deferred, 1s. 6d. per share of the dividend now recommended will be payable to the preferred shareholders, and 7s. 6d. per share to the deferred shareholders.

NEW COMPANIES REGISTERED.

Electrical Advertising Syndicate, Limited.—Registered by Frederick Bradley, 75, Mark-lane, E.C., with a capital of £10,000 in £10 shares. Object: to acquire certain patents relating to the application of electrical energy to the purposes of advertisements, and to develop the same. There shall not be less than three Directors. The first are the signatories to the memorandum of association. Qualification, 10 shares. Remuneration, £50, divisible.

T. L. Hemming and Co., Limited.—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £5,000 in £10 shares. Object: The acquisition of the business of an electrical and general engineer, now carried on by Thomas Lynch Hemming, John Thornton, and Thomas Richard Canning, trading as T. L. Hemming and Co., at 96, New John-street West, Birmingham, and to develop and extend the same. There shall not be less than three nor more than five Directors; the first are T. L. Hemming, John Thornton, and T. R. Canning—all of Birmingham. Qualification, 10 shares. Remuneration, T. L. Hemming, £250; other Directors to be determined in general meeting.

CITY NOTES.

Eastern Telegraph Company.—The receipts for April were £60,909, against £55,042 in 1890.

Brazilian Submarine Telegraph Company.—The traffic receipts for the week ended May 1 were £5,444.

Western and Brazilian Telegraph Company.—The receipts for the week ending May 1 were £4,363.

Cuba Submarine Telegraph Company.—The receipts for the month of April were £3,700, against £3,624 last year.

Eastern Extension Company.—The receipts for April were £44,729, an increase of £4,033, as compared with 1890.

West India and Panama Company.—For the half-month ended April 30 the receipts were £2,930, against £3,642 last year.

Direct Spanish Telegraph Company.—The estimated traffic receipts, for the month of April, amounted to £1,825, against £2,089 in the corresponding period of last year.

City and South London Railway.—The receipts for the last week were £733, as compared with £784, for the week ending April 25th. The total receipts for April were £3,328.

St. James's and Pall Mall Company.—The amount received for sale of current by this Company for the quarter ending March 31, 1891, amounted to £9,652, as against £1,818 for the corresponding period last year.

Consolidated Telephone Company.—The Directors recommend dividends at the rate of 6 per cent. on the preference and 7 per cent. on the ordinary shares, less income tax, making 6 per cent. per annum on both descriptions of shares for the year ending March 31.

Great Northern Telegraph of Copenhagen.—The traffic receipts of this Company for 1890 were £280,000, being a higher figure than in any previous year, which was principally due to the temporary rise in the value of silver, which had enabled the Company to effect their remittances from the far East at exceptional rates of exchange.

Great Northern Telegraph Company.—At the annual meeting, held at Copenhagen on April 25, the Directors' report was adopted, which recommended that the extra dividend, which, after the Berlin conference, had been reduced to 5s., should be increased by 2s. 2d., making the total dividend for the year 17s. 2d. per £10 share, or 8·60 per cent. A somewhat larger amount than usual was placed to the reserve fund in order to meet the heavy expenses in connection with the laying of the new cables.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅛
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Costa Rica.—An electric tramway is to be constructed in Costa Rica.

Schaerbeck.—An electric supply company has been established at Schaerbeck, with a capital of a million and a half francs.

Contracts.—The Great Eastern Railway Company are asking for tenders for telegraph materials and indiarubber, to be in by 23rd May next.

Woolwich.—The proposal to light the Board-room at Woolwich by electric light (by means of a gas engine) is deferred until the local company can supply.

Dunfermline.—The Dunfermline Town Council are proposing to buy up the gas works from the gas company, and a committee has been appointed to consider terms of purchase.

Austria.—The Grand Duke William, one of the cousins of the Austrian Emperor, has had his palace lighted from the Vienna central station by means of several hundred incandescent lamps.

Birmingham.—The shopkeepers outside the specified area in Birmingham are complaining about the restriction to more favoured customers. It is evident the area will require to be extended soon.

Obituary.—Professor Becquerel, son, and successor as professor, of Antoine César Becquerel, died on Monday, in Paris, at the age of 71. He published treatises on the solar spectrum, the electric light, magnetic phenomena, and other scientific subjects.

Telephone at Warwick.—The Town Council of Warwick, at their meeting on Tuesday, expressed their satisfaction that the National Telephone Company had decided (on sufficient support being given) to open a telephonic exchange in that town and connect it with their interurban system.

Proposed New Cable in the West Indies.—Mr. Gisborne, an electrician in the service of the Canadian Government, is now on a visit to the West India Islands to report upon the most feasible route for a cable connecting Bermuda, Demerara, Vera Cruz, St. Thomas, the Windward Islands, and Jamaica.

Aluminium.—Mr. J. H. Dagger read a paper before the Liverpool section of the Society of Chemical Industry, on the "Manufacture and Industrial Value of Aluminium." The various electrolytic methods and electric furnaces were dscribed, and two fine blocks of aluminium were exhibited by Hall's electrolytic process.

Royal Meteorological Society.—At the meeting of the Royal Meteorological Society, to be held at 25, Great George-street, Westminster, on Wednesday, the 20th inst., at 7 p.m., Mr. Shelford Bidwell, M.A., F.R.S., will exhibit an experiment showing the effect of an electrical discharge upon the condensation of steam.

Warwick Public Lighting.—The Mayor of Warwick has reminded the Town Council that the contract with the gas company for street lighting would expire in August next, and he suggested that the matter should engage the attention of the Highways, Watch, and Lighting Committee, which was agreed upon.

Grosvenor Gallery.—The electric installation of the Grosvenor Gallery of several hundred lamps has lately been rewired by Mr. H. E. Winter, some years ago foreman to the Grosvenor Gallery Company, who has since been out to South America on a Ferranti installation, and is now setting up business as electrical contractor.

Telephone Price Lists.—We have received the price list, with instructions, and illustrations of many types of telephones, from Messrs. Gent and Co., of Faraday Works, Leicester. The pamphlet contains details of instruments, parts, wires, and fixings for private telephones, with very clear diagrams of the method of running wires for various uses.

The Telephone in Lincoln.—It was mentioned at the third annual meeting of the Lincoln Chamber of Commerce, that Lincoln would shortly be in telephonic communication with other towns, and that the Chamber had helped to bring this about by putting the pressure which it did on the telephone company itself, and then assisting by obtaining wayleaves.

Subway in Sheffield.—The Highway Committee have instructed the borough surveyor to obtain all possible information as to the time likely to be occupied in, and the cost of, constructing a subway, a distance of about 300 yards; the subway to hold sewer, gas, and water pipes, telephone, telegraph, and electric lighting wires, pneumatic tubes, power tubes, etc.

Switches.—The progress of electric lighting generally is shown by the great demand for switches and switchboards. Messrs. Poole and White have as many as 76 large switchboards on order, and are having to extend their premises considerably. Orders for small switches are coming in regularly at the rate of five or six hundred a day, and 5,000 have been sent off this week.

Telephones and Fire Alarms in London.—The Fire Brigade Committee of the London County Council report that they have received from the Post Office an intimation that the charges for the maintenance of fire alarms and of telephonic communication between fire stations will be reduced as from the 1st ultimo. The reduction will amount to about £800 a year.

Bury (Lancs.).—The Parliamentary Committee of the Bury County Council have appointed the Mayor, Aldermen Burrow and Mellor, and Councillors Hopkinson and Maxwell as a sub-committee to enquire what is the demand for electric light in the compulsory area, to consult with an electrician, and report as to the advisability of the Corporation undertaking the works for supply of electric light.

Standard Cells.—Prof. H. S. Hering has given the result of continued experiment in a paper to the Franklin Institute on "The Effect of Atmospheric Pressure on Batteries," which seemed to show that the E.M.F. of standard cells did not become really constant until about two hours after setting up, owing to the barometric action of the atmosphere. This result elicited considerable discussion.

Polytechnic Classes.—During the summer, electrical evening classes will be held, at very low fees (1s. 6d. per course), at the Polytechnic, Regent-street, under the direction of Mr. W. Hibbert, F.I.C., A.I.E.E. These will include lectures on "Electric Bells," on Mondays, by Mr. G. C. Cripps; on "Electro-metallurgy," on Tuesdays, by Mr. W. Thorrowgood, A.I.E.E.; and on "Electric Lighting," by Mr. Field, on Wednesdays.

Deptford and the Post Office.—Mr. Preece states in his interesting paper that the Post Office officials are now quite unaware whether the Deptford mains were working or not. He adds it was not always so; and in illustration of this we may relate that Mr. Ferranti once received a telegram from Mr. Preece stating that it was sent by means of the Deptford currents, no other battery being on—a feat which astonished the Deptford engineers not a little.

Royal Society.—The following 15 candidates have been selected by the council of the Royal Society to be recommended for election on June 4: Mr. W. Anderson, Prof. F. O. Bower, Sir J. Conroy, Prof. D. J. Cunningham, Mr. G. M. Dawson, Mr. E. B. Elliott, Prof. P. F. Frankland, Mr. P. C. Gilchrist, Dr. W. D. Halliburton, Mr. O. Heaviside, Mr. J. E. Marr, Mr. L. Mond, Mr. W. N. Shaw, Prof. S. P. Thompson, and Captain T. H. Tizard.

Frankfort Exhibition.—The International Electrical Exhibition at Frankfort is to be opened on Saturday with considerable pomp. The Archduke of Weimar has kindly put at the disposition of the Exhibition Committee, for the duration of the exhibition, the electrical machine with which Goethe made his experiments, and which is usually kept in the Goethe Museum at Weimar. This interesting relic will be on view in the hall of medicine and science.

British Association.—A meeting of the general committee appointed to arrange for the reception of the British Association in August was held in Cardiff last week, under the presidency of the Marquis of Bute. The report showed that £2,350 had been received from less than 100 members, and promises for the accommodation of about 100 guests had been received. Prof. H. W. Lloyd Tanner mentioned that the meetings would commence on a Wednesday, and be continued till the Thursday week following.

The Frankfort Journal.—The Frankfort Exhibition authorities are issuing, as we have already mentioned, a special journal of their own during exhibition time. A curious mistake has got into its second number. Prof. Silvanus Thompson was asked to act on their committee, and on publishing the portraits of these gentlemen (apparently without consultation with them) the revered and well-known features of Sir William Thomson are made to appear by a curious error over the name of Dr. S. P. Thompson.

Durable Telegraph Poles.—In the obituary account of Mr. Richard Wright, of High Lodge, Richmond, Yorkshire, whose death is just announced in his eighty-sixth year, it is mentioned that, besides being a well-known horse breeder, he was an inventor, amongst other things, of new methods of making boots, which revolutionised the trade. Lately he had turned his attention to electrical matters, and his most recent invention was "durable telegraph poles which would, by their adoption, avert the accidents caused by the present system."

Florence.—The electric tramway from Florence to Fiesole, the scene of a terrible accident a few months ago, has now been reopened after the cars have been fitted with a new system of breaks. The old breaks were controlled by the line current, which might fail just when the car was descending. The new method of safety break devised by Mr. Sprague is said to consist of the use of the current generated by the revolution of the armature on the car wheels, which acts the more energetically the greater the speed of the car.

Surface Leakage.—As parallel lighting on the low-tension system increases, the importance of surface leakage will become more and more prominent, and steps will have to be taken to see that contractors use highly-insulated fittings. Almost each lamp necessitates a switch, cut-out, and holder, and the total leakage per 1,000 lamps is sometimes too much to be endured by the company. We have recently heard of an installation for 300 lamps in which, by good fittings, the total insulation when finished with all lamps was 20 megohms. We do not think this need be much improved upon.

Leeds Municipal Buildings.—On Friday last a meeting of the Corporate Buildings Committee of the Leeds County Council was held, at which the question of the electric light in the Municipal Buildings was discussed. It was reported that the installation needed renewal, but nothing definite was decided upon by the committee, the matter being adjourned till to-day. At the same meeting the defective ventilation of the room in which the dynamos are placed was also under consideration, and it was agreed to recommend the General Committee to carry out some improvement. Here is evidently a chance for the electric motor and ventilators.

West Metropolitan Tramways.—A Select Committee of the House of Commons has passed a Bill extending the time for the completion of the West Metropolitan Tramways in Hammersmith, Chiswick, Acton, and Ealing to August next year, and also obtaining powers to work the lines by electricity. The only petitioners against the measure were the National Telephone Company, who, supported by the evidence of Sir William Thomson and Sir Frederick Bramwell, succeeded in obtaining the insertion of a clause compelling the tramway company to insulate their wires in such a way as not to interfere with the working of the telephone system.

Smith's Tables and Memoranda.—This is the fifth edition of Mr. F. Smith's excellent little pocket-book, issued by Messrs. Crosby Lockwood and Son. A new section has been added, giving the more important electrical tables and formulæ. One great advantage of this book is its handy size. Many of the pocket-books are too large. The compilers are too anxious to insert everything likely to prove useful—in fact, to make the book partake of the character of encyclopædias rather than aids to memory. Mr. Smith has managed to put a vast amount of information between covers that will conveniently go into the waistcoat pocket. A good index is given.

Roundhay Park Tramway.—At a meeting of the Highways Committee of the Leeds Corporation last week, the chairman (Alderman Firth) and the town clerk (Sir George Morrison) reported the result of an interview they had had in London with the representatives of the Thomson-Houston International Company, with which an arrangement has been made in respect to the running of electric cars on the Roundhay Park tramway. The company intend to send their plant and commence operations without further delay, and it is hoped that the cars may be running before the bank holiday in August. The agreement, embodying the above arrangement between the Highways Committee and the company, was signed by both parties on Wednesday.

Western Counties Telephone Company.—At the meeting of the shareholders in this company, which is to be held to-day at Bristol, the directors will be able to submit a very satisfactory report, which will be found in another column. In every direction there seems to have been an extension of business. The Western Counties Company is happy in having at its head a gentleman whose sole endeavour is to make the telephone of use to the public, and who is accordingly making his system a success. We allude, of course, to Mr. Lewis, of whom we have frequently spoken in terms of high praise. It will be seen that the company increased the mileage of trunk and renters' wires by 903 miles in 1890, and the number of their subscribers and private line renters by 524.

New Constant Primary Battery.—A business has been established by Messrs. Osborne and Co., electrical and chemical engineers, at Pleasant-place, Essex-road, more especially to put upon the market a new form of primary battery, which they are just bringing out. This battery, they state, will run constant for from 30 to 60 hours, giving a current of from 10 to 36 amperes, according to the size of cell, the chief cost being for the zinc, as the depolariser only costs 3d. per Board of Trade unit. As a sample of the cell, they quote a set of six cells contained in a case 12in. by 8in. by 8in., gives a constant current for 30 hours of 18 amperes at 9·5 volts, having a fall of only 5 per cent. at the end of 26 hours. We are promised a sample set to test, and should think if these promises are borne out the battery would have considerable usefulness.

Funeral by the Electric Light.—On Tuesday, the 5th inst., at the quaint old church in the grounds of Twyford Abbey, near Ealing, Middlesex, which has recently been electrically lighted by Ronald A. Scott, of Acton Hill, the remains of Mrs. Margaret A. Douglas-Willan, of Farquhan-road, Norwood, one of the original owners of the Abbey, were interred in the family vault. The vault, which contains 14 coffins, and extends for 30ft. under the church, was brilliantly lighted with incandescent lamps. The effect was striking in the extreme, and every screw head and nail in the old oak coffins (some of which are over a hundred years old) could be easily distinguished, and the death-chamber seemed to look quite cheerful. The electric current was carried by overhead wires from the Abbey, and flexible wires, with artistic coloured shades, were used in the vault. We should fancy that this is the first funeral at which the electric light has been used to illuminate the vaults.

The Brush City Offices.—The Brush Electrical Company have now got their City offices in Queen Victoria-street, opposite the Mansion House Station, into working order, and make a fine show of machinery—part shown in motion—and of fittings of many kinds. There are several vertical engines coupled, as used in practice, to Victoria incandescent dynamos and Mordey alternators. The show-room is abundantly fitted with switches and with a handsome assortment of incandescent lamp fittings. Downstairs in the basement is a 6-h.p. Otto gas engine driving a Victoria machine giving 50 lights at 60 volts, the current from which is used for lighting a large arc lamp outside in the street, and for incandescent lamps in the subway which exists along Queen Victoria-street, in which the new electric mains for the City are being run. The dynamo also supplies current for running the dynamos in the showroom as motors as well as a small yacht motor, making a very effective show of machinery in motion.

The Demon of the Strand.—Tradesman, *loquitur:* "Hang these electric light companies. How on earth can business go on with this pandemonium of trestles, picks, poles, trenches, and stenches. One wouldn't mind if it was only once, but this is the fourth or fifth time within a few months. See that ruddy, stout-built fellow in the serge suit standing by that evil-smelling cauldron? Well, he's the man? We've christened him the 'Demon of the Strand.' He'll clear off with his bitumen pot and paraphernalia; and then business will get brisk, and the streets begin to look right again. But in a morning or two the same beastly stench and thick smoke, and the road in rucks and heaps, and we know the 'Demon' is back again, and we are in for another three weeks' misery. And the worst of it is that it's no use complaining; the 'Demon' only smiles sarcastically and tells us the smell's good for our health. Bah! I should like to boil him in his own cauldron!" Exit for a refresher.

Manchester Town Hall.—The Manchester Gas Committee invite tenders, with full descriptive particulars, for lighting the Town Hall by electricity. The tenders are to be divided under two heads—viz. (1) to supply and fix the whole of the fittings and all necessary connections and appliances required to light the various rooms and corridors; (2) to supply and fix the motive power, such as gas engines, dynamos, and all plant, etc., necessary for the production of the electric light. In each case the amount must include all cost for superintendence, keeping in good order, and working the same for 12 months, at the end of which time the plant, etc., must be left in perfect working order. In preparing the tenders intending contractors must bear in mind that the motive power (engines, etc.) will be removed from the Town Hall when the larger installation to be supplied for the city is carried out. This must also be kept in view in the supply of the fittings, so that they can be made use of when the contemplated further installation is completed. The rooms to be lighted will be pointed out on application to Mr. Rison, steward, Town Hall (Mondays to Fridays inclusive), between 9 a.m. and 5 p.m. Sealed tenders must be delivered at the Town Hall by 17th June. Further particulars are given in advertisement.

Transmission of Power in Scotland.—Messrs. M'Whirter, Ferguson, and Co., of the Faraday Electrical Works, Govan, have just completed an order which marks the progress being made in the application of electricity to the purposes of industry. Plant for the electrical transmission of power for mining work has been constructed for Mr. John M'Culloch, of Leganlea Collieries, near West Calder. At the collieries a new engine house has been erected, and in it has been placed a horizontal engine of nearly 100 h.p. A dynamo capable of yielding 60 e.h.p. at a pressure of 200 volts has been supplied by Messrs. M'Whirter, Ferguson, and Co., the electricity from which will be carried down the mine in cable manufactured by the Fowler-Waring Company. Descending the shaft, the first branch from the cable will be carried to a small motor used for hauling in a gallery at present half a mile in length. At the bottom of the mine a large road, to be used in working the main seams, is being driven through the solid stone. A motor of 30 h.p. will do the bulk of the hauling here. The water met with in the construction of the road will be pumped to the surface by means of another motor of 15 h.p. When the installation is complete it is estimated that Mr. M'Culloch will have at his command about 150 h.p., capable of being applied not only to the purposes mentioned, but to rock-drilling, coal-drilling, and coal-cutting. It will also serve to light up the whole of the extensive works. The installation at Leganlea, it is believed, is the first of its kind in Scotland.

Bath.—The Bath Surveying Committee have again had before them last week the report of Prof. Forbes on the electric installation. The Electric Lighting Committee report that ground-glass globes were recommended, and have been adopted. Prof. Forbes says "the total quantity of light given by each arc lamp is certainly not more than the total quantity given by 300 or 400 candles," though he afterwards acknowledged that the lamps might test in their best position to 1,200 c.p. He believes that the contract with Mr. Manningham has been properly carried out, and that private lighting can be maintained in a satisfactory condition, except for the absence of automatic regulation mentioned. The public lighting he considers as satisfactory as could be expected from the terms of the contract, though not equal to best Continental and American practice, 6·8 ampere lamps being used instead of 10-ampere lamps, and these rather far apart. The Electric Committee advised the adoption of Prof. Forbes's recommendation—viz., that a competent engineer should be engaged to periodically inspect and report; and that about 12 more lamps should be added. Mr. Sturges moved the adoption of the report, remarking that the total power of a gas lamp is not equal to its test power. He considered the report, on the whole, very favourable. Mr. Massingham gave some particulars as to the light and the absorption by ground-glass globes. The omission of the recommendation for additional lamps was proposed as an amendment, but the report, as presented, was finally adopted.

Electric Tramways for Walsall.—At the quarterly meeting of the Walsall Town Council on Monday, the Street Committee recommended that the committee should be empowered to consider the negotiations with the South Staffordshire Tramways Company with reference to the proposed adoption by the company of the overhead wire system of electric traction. Alderman Newman proposed the adoption of the recommendation, and said the great advantage of the adoption of the overhead system would be that the heavy lumbering engines, with their noise, smoke, and fumes, would be done away with, and probably a quicker service be obtained, which was very important. The committee had been unable to recommend the Council to give their consent to the scheme without further information, and they considered that such information should be obtained by some independent competent person being sent to America to examine into the systems in operation and report fully to the Council. The company had agreed to pay a sufficient sum of money to defray the cost of sending out Mr. F. Brown, who was advising the Council on the matter of the proposed electric lighting system, to make the desired examination of the electric tramway systems in operation in America, and report whether the company's proposal was a practicable one, and could be worked without danger of annoyance on the lines within the borough. He proposed a resolution to this effect, and that the further consideration be postponed until after the receipt of the report. The motion was carried.

Overhead Wires at Sheffield.—Major P. Cardew, R.E., has made a lengthy report with reference to electric lighting and overhead wires in Sheffield. This has been laid before the Board of Trade, and a copy of it forwarded to the Parliamentary Powers Committee of the Sheffield Corporation. Major Cardew reported that the insufficiency of the insulating covering for the wires was a very serious departure from regulations. He had had some experience with insulation of this character, and considered it utterly untrustworthy when it had become saturated with water and after exposure in air for lengthened periods. He found a good system of testing was in use, and when the insulation showed any unusual leakage prompt steps were taken to remedy it. He considered the careful system of testing and maintenance considerably diminished the risks, but he could not view the use of such wire, as he had referred to, in a crowded town, without apprehension. Besides the protection of the public, that of the persons supplied and their employés had to be considered, and in respect of this he could not say that the present arrangements were satisfactory. In all cases where the wires were liable to be touched by shop assistants and other persons ignorant of the possible danger they should be suitably protected. The Parliamentary Powers Committee, on the receipt of this report, instructed the town clerk to write to the Sheffield Telephone Exchange and Electric Light Company and enquire what they were doing with regard to matters mentioned in the report. They also passed a resolution expressing the opinion that it was desirable that all wires for the supply of electric light should be carried underground. This has been forwarded to the Board of Trade.

City of London Generating Station.—Interest is now becoming rife amongst electrical engineers with reference to the generating station for the City of London lighting, now, perhaps, one of the most important contracts on hand in the electrical world in this country. We have, therefore, had a look in at the work to report progress. Passing behind the Mansion House railway station, and crossing Southwark Bridge, one comes to Bankside, an interesting part of old London little frequented by City men, full of wharves and manufactories, on a site rendered classic by Shakespeare's old Globe theatre. Turning along to the right along the bank, till one is exactly opposite St. Paul's, which looms magnificently in an unaccustomed view across the river, we come to Meredith's Wharf, where the new City of London generating station is situated. The men are busily at work in the road laying mains, and a close heap of pipes of various sizes from 1½in. to 3in. are huddled together, newly tarred, in a deep trench, to the number of 19 or 20 separate pipes. A large open site, cleared of buildings, has been taken, and work is busily progressing in many directions. Only part of the site is yet covered with buildings, and to the right-hand corner the first generating station is nearing completion. The large square chimney is finished; the walls are built, and the wrought-iron pillars carry the rafters of a wide roof. In this building men are busily at work laying foundations of engines, fitting the engines, and laying mains. The foundations and parts of two engines, each of 65 h.p. nominal, indicating up to 150 h.p., are laid. These will each drive two 60-light Brush arc light dynamos. Other engines will drive a couple of Mordey alternators, and eight dynamos in all will be erected in this building. Two Babcock and Wilcox boilers (140lb. pressure) are swung in frames high in air, while their sets of tubes are ready for fixing. The grounds are covered with heaps of iron pipes, parts of lampposts, etc., and the flywheels of the engines are ready for fixing. The work seems to be well forward in what is necessary for the stipulated time of starting. A second building will contain 26 engines of an aggregate of 800 h.p., chiefly for private lighting.

Preston.—A meeting was convened by circular at Preston on May 7 to invite subscriptions for shares in the National Electric Supply Company, in order that the electric plant might be of a permanent character. The Preston Corporation, it was mentioned by Mr. Rylands, had given the National Company encouragement. A provisional order was obtained, and temporary plant put down. The light was so satisfactory it was now determined to have a permanent plant. It was considered that a capital of £40,000 would put up a first-class installation for 10,000 lights, and £5,000 to £10,000 would be required as working capital. It was desirable to form a local directorate of Preston business men. Mr. Emmott, engineer to the company, said his figures were based on facts. The £40,000 for 10,000 16-c.p. lamps included £4,000 for contingencies. The income he gave at £10,500 a year, which, after deduction for maintenance, would leave a 15 per cent. dividend. In Halifax a central station had been started, which had a capacity of only 2,000 lights. The result was so satisfactory that they had decided now to put down a plant of twice 10,000 lights. The Corporation of Bradford had put down their own plant. Before the end of the first year they had to provide for double the capacity. Leeds had arranged to have the whole of the borough lighted. He thought this showed clearly that it was only a question of time before every house would be supplied with electric light. Mr. Toulmin asked what relationship the proposed company would have with the National Electric Supply Company. Mr. James said the National Electric Supply

Company would be a company for Preston. It would be competent to make provisional orders for any other town, and was not bound to stop at Preston. Their wires were now overhead, but they intended to lay them underground. The real element of success was when local people were concerned in the lighting. Mr. Alderman Forshaw explained that there was a company existing. If they created a new company there would be fresh expenses. Instead of that they were going to have the old company. They were to become shareholders along with the gentlemen who were now shareholders. They wanted to localise the company. Although the company was floated for Preston, it could, if it so chose, at some future time apply for electric light power elsewhere. This new company was for making permanent in Preston that which was more or less temporary. The meeting then concluded.

Electric Lighting Systems in London.—Before the Royal Scottish Society of Arts, at Edinburgh, on Monday, Prof. Alexander B. W. Kennedy, F.R.S., engineer-in-chief to the Westminster Electric Supply Corporation, read a paper entitled "A Description and Comparison of the Systems of Electric Lighting at present in use in London." There were, he said, in London a number of electric companies, each working in its own special district, under its own special Act of Parliament, and in its own way, with the necessary restrictions for the public safety. The intention of each of these companies was that of simply supplying the electric current as gas companies supplied gas. They built central stations in which the electricity was generated, and laid mains along the street. The current was measured by meter, and paid for by meter exactly as gas was. No doubt the accuracy of the electricity meter was not yet all that it ought to be, but even the ordinary domestic gas meter did not, he believed, possess the accuracy of a scientific instrument. The pressure in the houses was always a low pressure, and was practically fixed at 100 volts. The companies in London might be classed as those using the high or low pressure in their mains, or as those using what was called the continuous or the alternating current. He did not think that any one system presented all the necessary merits; it did not follow that the system which was the best for one district would be good for another. The high-pressure system had the gain that the central station was away from London altogether, but had the loss that the current had got to be transformed three times instead of once, and in everyone of the transformations a certain amount of energy was lost. The low-tension system was simpler, because these companies did not require to transform the electricity at all. Regarding the price of electric lighting in houses and in streets, Prof. Kennedy said that the change from gas to electricity was never made except for the purpose of obtaining a very much greater illuminating power, and that being so, the cost would be about four or five times that of gas. As to private lighting, so much depended upon the amount of economy exercised in the use of electricity that the cost might not be much more than that of gas, or it might exceed gas at 3s. by 25 or 30 per cent. In hotels and clubs, where the same economy could not be practised, the cost of electricity could hardly be less than double the price of gas at 3s. The actual cost of electric light was known to a great exactness to be ¼d. an hour for an eight-candle light, or ½d. an hour for a 16-candle light. At the close a number of questions were asked, and Prof. Kennedy was cordially thanked for his lecture.

Glasgow.—The report of the Special Sub-Committee on Electric Light came before the Glasgow Town Council on May 7th. The sub-committee having considered reports submitted to them by Sir Wm. Thomson, Prof. Jamieson, and Mr. R. E. Crompton, recommended that the Town Council should, instead of transferring their powers to any outside company, themselves undertake the laying down of the necessary works for generating electricity for private and public lighting within the compulsory area of the city under such professional advice and superintendence as may be deemed requisite or expedient; and that if the recommendation is approved of, arrangements be made for acquiring a suitable site for the erection of a central supply station. As will be seen from the report by Mr. Crompton, the cost of putting down the plant requisite for supplying 11,000 16-c.p. lamps (exclusive of cost of sites for central station and sub-station) is estimated at £51,307. Mr. Crompton's scheme proposes that the Corporation should purchase land or pay ground rent for a site in a central position, with a plot 18 yards frontage by 30 yards depth. "I have prepared," he says, in his report, "complete designs to place on such a site the generating machinery, which could supply at once 10,000 16-c.p. lamps burning simultaneously, allowing space for future extensions up to 25,000 lamps. I have allowed £5,000 as the cost of a substantial building of three floors, with a chimney 130ft. in height. On the ground floor will be placed a range of boilers of the dry back marine type, each about 200 h.p., that is to say, having 1,000 square feet of heating surface. On the same floor arranged parallel to the boilers I place on substantial foundations a row of steam dynamos, each of 200 h.p. In addition to these, I supply two small steam dynamos, each of 90 h.p. My estimate of the scheme provides for six 200-h.p. boilers, five 200-h.p. engines, and two 90-h.p. engines. The engine and boiler room to be provided with suitable travelling crane and other necessary tools, also with the switchboards and instruments for measuring the current and distributing it to the mains. On the first floor, extending over the whole of the engine and boiler room, would be space for the home batteries of accumulators, and for stores and workshop. Over this can be placed rooms for the resident engineer in charge and the offices. I propose to put down one sub-station to contain two batteries of accumulators. If the local circumstances in Glasgow will admit of the use of the system of bare copper conductors strained in culverts, which I have applied with success in London, I should strongly recommend it. In case, however, the local conditions at Glasgow are such that these culvert mains cannot be employed, I can use two other alternative methods of laying the conductors; one, that of drawing insulated cables into pipes laid in the streets; and the other, that of using the patent bitumen trough system, invented and successfully employed by Messrs. Callender in Liverpool, Birmingham, and other towns. One point that has received my careful consideration is the probability that you will be able to obtain an output of 800,000 units per annum from the 10,000-light plant proposed. In a table accompanying the report the cost of the generating plant is estimated at £23,636, storage at £6,850, distribution at £16,161, engineers' fees, etc., at £4,660, making a total of £51,307." Sir Wm. Thomson, in his report, says that "for lighting the compulsory district the low-tension direct-current system is decidedly preferable to the high-tension alternate-current system with transformers, and is the system that ought to be adopted." The report of the sub-committee having been submitted, Councillor Ure asked that the report and recommendation be held over till next meeting, to give the members an opp [illegible] considering the question. This [illegible]

ELECTRICAL DISTRIBUTION.

At the Royal Society's *conversazione*, Messrs. J. E. H. Gordon and Co. exhibited Tomlinson's improved method of electrical distribution.

It has long been recognised that the distribution of electricity by alternate current and transformers specially lends itself to dealings to the wide and extended areas found in modern towns, owing to the small first cost of the mains as compared with those used in the direct-current system. Against this saving of first cost is to be placed the continuous loss which occurs in the ordinary transformer system, owing to the waste of current in the transformers, which are always connected throughout the 24 hours, although they are only in use for perhaps an average of two hours per day.

It has been proposed to obviate this loss by collecting the transformers in what are called sub-stations, and in the idle hours of the day to disconnect those transformers which are not required for use.

This system has been adopted in Rome with success, but there have been great difficulties in applying it generally—first, owing to the cost of labour in connecting and disconnecting the transformers, and, secondly, owing to the increased capital cost which it has been supposed would be incurred, particularly in scattered districts, by applying the system.

So formidable have these difficulties appeared that various supply companies have commenced operations by laying their mains upon the old system, intending to use it as long as the customers are few and scattered, and to alter it to the new system when the density of supply increases. This plan is open to the very serious objection that it involves a heavy expenditure of capital in reopening streets and relaying mains throughout the district just about the time when the earlier shareholders might reasonably hope to commence to receive good dividends.

The improvements which Messrs. Gordon and Co. are introducing are—first, a method of connecting and disconnecting transformers without the employment of labour in the sub-stations; second, an arrangement of mains such that the first cost of the sub-station system does not exceed the first cost of the scattered transformer system, thus enabling companies to adopt it at once when pioneering in a new district.

THE SUB-STATION REGULATING APPARATUS.

This is the invention of Mr. Thomas Tomlinson, B.E., chief engineer of Messrs. Gordon and Co., and is represented in Fig. 1.

The requirements of a practical apparatus are as follows: First, it must use mechanical, and not mercury contacts. Second, it must be able to make and break circuits carrying the heaviest currents without any sparking whatever. Third, if any one of the switches accidentally becomes heated it must at once be short-circuited and thrown out of action. Fourth, if any accident or breakdown whatever occurs to the apparatus, every transformer must at once be put into circuit. The condition is absolutely essential, and is the most important feature of the new apparatus.

It is well known that any mechanical apparatus is liable to failure. If an apparatus such as we are describing fails while taking transformers out of circuit no harm is done beyond a waste of coal, but if a failure were to occur when putting them into circuit it would probably cause a fire and the destruction of the sub-station. It will be seen below how the new apparatus entirely guards against this source of failure.

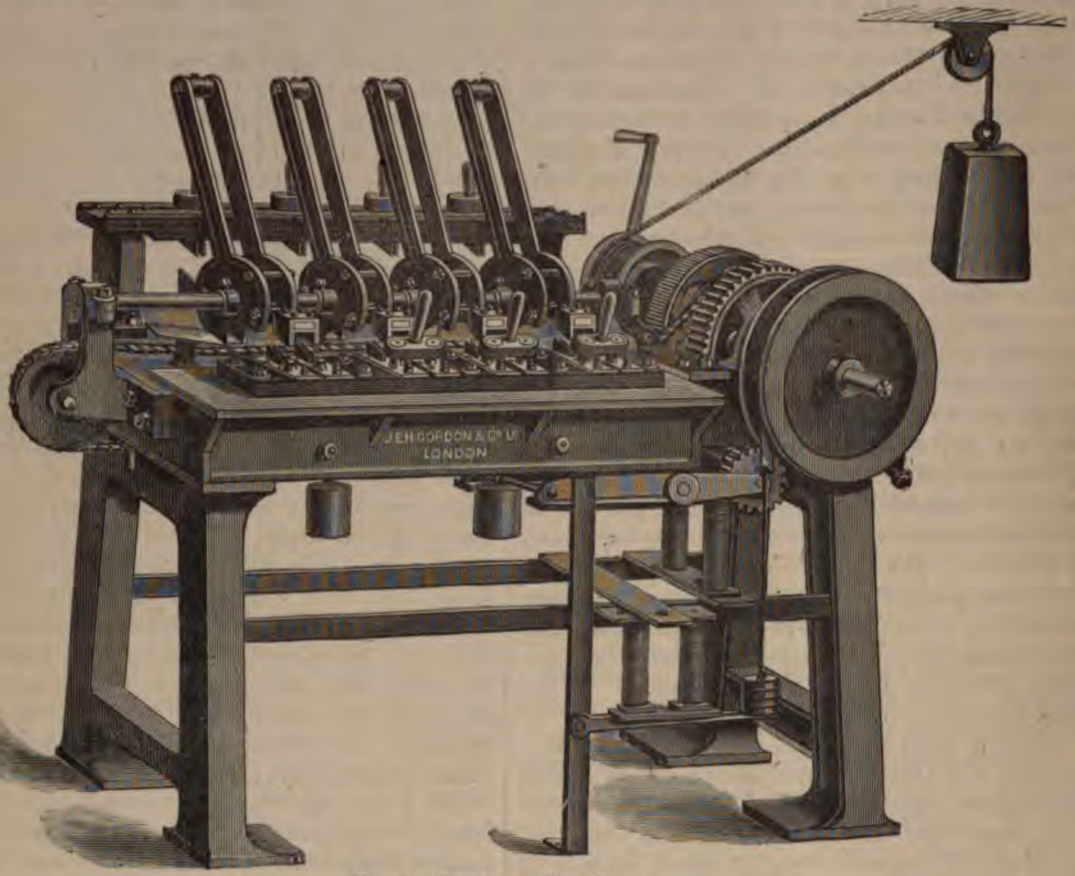


FIG. 1.—Tomlinson Regulator.

The Tomlinson apparatus is provided with four sets of switches, and the transformers are arranged in five groups. One group is permanently connected to the mains and one more is connected through each set of switches respectively. The transformers are grouped as shown in Fig. 2.

Suppose that one transformer is permanently connected to the mains, then one would be connected to the first switch, two to the second, four to the third, and eight to the fourth, so that the putting in of each switch doubles the number of transformers in circuit.

The switches are arranged to break the primary and secondary circuits simultaneously. The extra currents produced being in opposite directions, all sparking is prevented. With a current of 1,500 lamps on a single switch no spark whatever is visible. The switches are thrown over by a sliding carriage in the form of a double wedge, which runs backwards and forwards along the bed-plate of the machine, and as it passes each switch, throws over a tumbling lever, which strikes the switch suddenly in or out of contact.

This carriage is moved by an endless chain actuated by two weights, which are released respectively by two electromagners. The large weight which takes transformers out of circuit has to be wound up once a week, and, as it takes out the transformers, it at the same time winds up a smaller weight ready to put them in again. If any failure whatever of the large driving weight occurs, or if the attendant forgets to wind it up, the small weight is always ready to put the whole of the transformers into circuit, and must do this before the apparatus becomes inoperative.

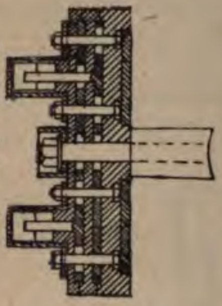


FIG. 3.—Safety Fuse.

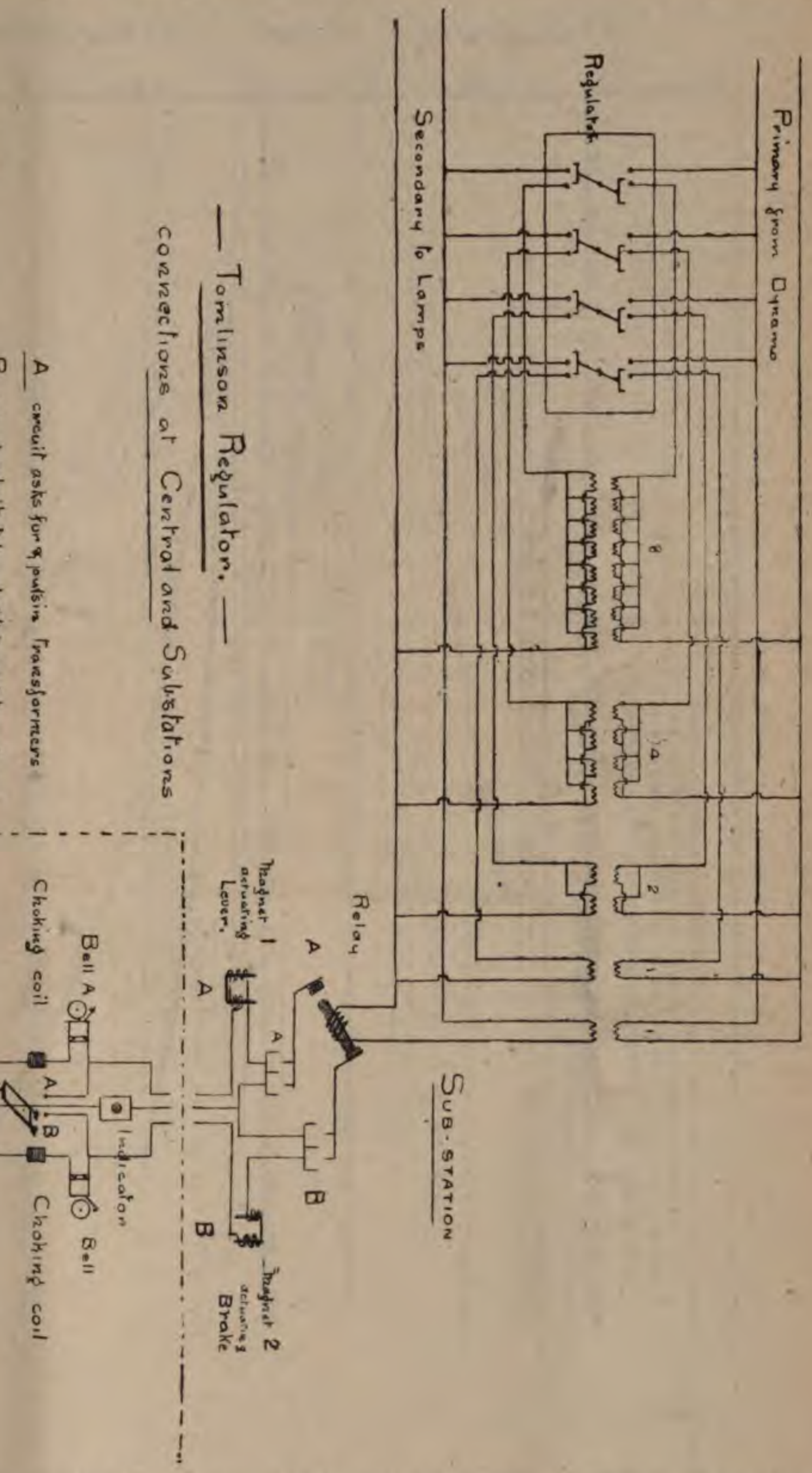

Primary from Dynamo
Regulator
Secondary to Lamps
8
4
2
1
1
Relay
A
Magnet 1 actuating Lever.
A
A
B
Magnet 2 actuating Brake
B
SUB-STATION
Tomlinson Regulator.
connections at Central and Substations
A circuit asks for & puts in transformers
B circuit asks to take out & takes out transformers
Indicator
Bell A
A
B
Bell
Choking coil
Choking coil
CENTRAL STATION
Central station lighting circuit.

FIG. 2.—General Diagram of Connections.

Of the two cogwheels seen on the right of the machine, the one with large teeth is keyed to the shaft, and the one with the small teeth is loose on the shaft, but is fixed to the wheel over which the endless chain passes. The two cogwheels are brought into gear with each other by means of two pinions fixed on the same spindle, and attached to the end of a rocking lever actuated by an electromagnet. The cogwheel with the large teeth is always in gear with the pinion, but when the lever is attracted by the magnet the small-toothed cogwheel comes out of gear with the pinion, and allows the small weight to fall and put the switches in.

Except when there is a current in this magnet, the wheels are in gear with each other, though the pinions and the whole system is kept at rest by the brake seen at the far side of the machine. When a current is sent through the lower magnet this brake is released and the large weight falls, turns the spindle, and through the cogwheels draws the carrier back and takes switches out. At the same time it winds up the small weight, leaving it ready for putting the switches in again at any time.

In case any switch should get hot, it would be short-circuited by the cross pieces seen in Fig. 1, and shown in section in Fig. 3. These consist of hollow brass boxes mounted on an insulating frame, each box being electrically connected to a rod projecting inside the other box. Each box is lined with paraffin wax and filled with mercury. In case of heating, the paraffin melts and floats to the top of the mercury, which establishes a contact, and puts the switches out of action and puts transformers into circuit.

The method of actuating the apparatus is seen in Fig. 2. A double relay is provided, placed in the secondary circuit of the fixed transformers. As soon as the current exceeds full load a contact is made, and a small current is sent through one of the magnets of the apparatus along a wire to the central station, where it passes through a choking coil and bell. On the bell ringing, the attendant knows that more transformers must be put in, and he puts down a switch, which short-circuits the choking coil and bell, and allows a sufficient current to pass to actuate the magnet and put a sufficient number of switches in. If the attendant should inadvertently hold down his contact-key too long, the mistake will be corrected by the apparatus, as the circuit will break at the relay, and the machinery will cease to act. The magnet for taking out transformers is actuated in a precisely similar manner by the other part of the relay, which acts when the current in the fixed transformers falls to less than half load.

In order to test the practical value of this apparatus, a plant of 1,950 8-c.p. lights' capacity was, by the courtesy of the Brush Company, erected in their works, and connected to transformers, kindly lent for the experiment by the Metropolitan Electric Supply Company.

The plant was first run for 24 hours with the transformers connected in the ordinary manner, and then for 24 hours with them connected through the Tomlinson regulator, and coal and water were measured throughout the experiments As, owing to the temporary arrangement of the engines, the waste of power in friction was consider-

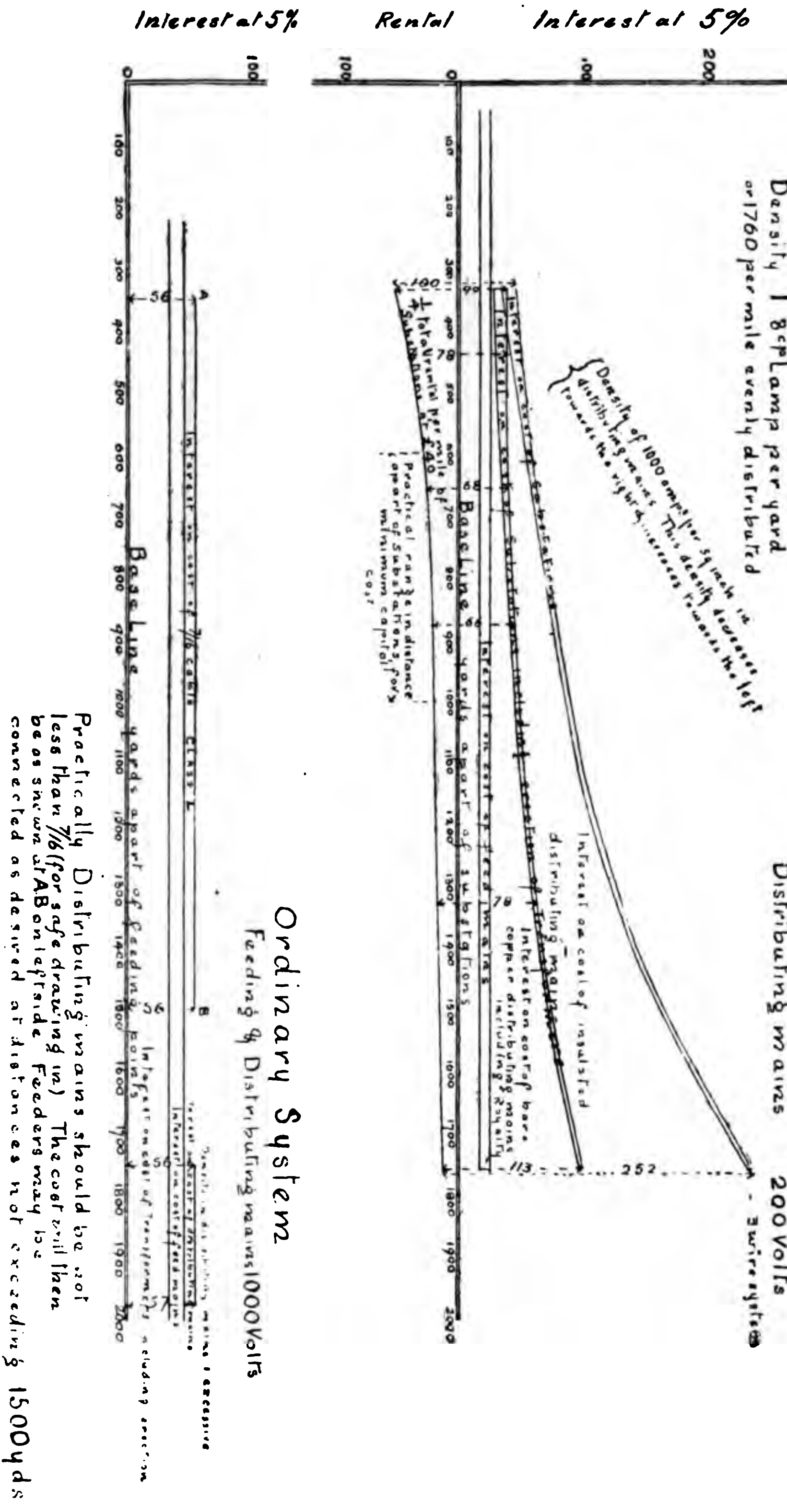


Fig. 4.—Relative Capital Cost of the Two Systems.

able, a preliminary experiment was made to find the coal used in running the engine, countershafting, and dynamo light, and this quantity was deducted from the results obtained in the two experiments respectively.

The electrical load was varied according to the ordinary requirements of the London stations (what is known as a 12·2 load factor being employed). The net result of the experiment was, that with the new apparatus 12¼cwt. of coal were used in the 24 hours, and without it 16½cwt., showing a saving of 26½ per cent. of the coal. From this the actual saving of coal per 8-c.p. lamp per year can be calculated; and it will be seen that it amounts to 89lb. of coal, or in money 10½d. per lamp per year. The average capital expenditure of a supply company is about £2. 5s. per 8-c.p. lamp, and this saving of 10½d. is, therefore, equal to 1¾ per cent. per annum on the capital which would be available to increase the dividends of the supply company.

It has often been urged, in reply to advocates of the sub-station system, that although its adoption would be useful when the density of lighting in any district becomes heavy, that in a scattered district the first cost would be prohibitive.

Figs. 4, 5, 6 shows that this would not be the case. The curves represented in them are produced from actual figures taken either from contracts in progress or from tenders which have been sent in. These figures represent the capital cost for three different densities of distribution, and for different distances apart of sub-stations.

As the rent of sub-stations, which is an annual charge, is an important consideration, the other items of expense are placed not directly as capital expenditure, but at the rate of 5 per cent. per annum on the capital expenditure. The horizontal line represents distance apart of sub-stations, the vertical lines above the base line represent 5 per cent. interest on the various items of capital cost for one mile of

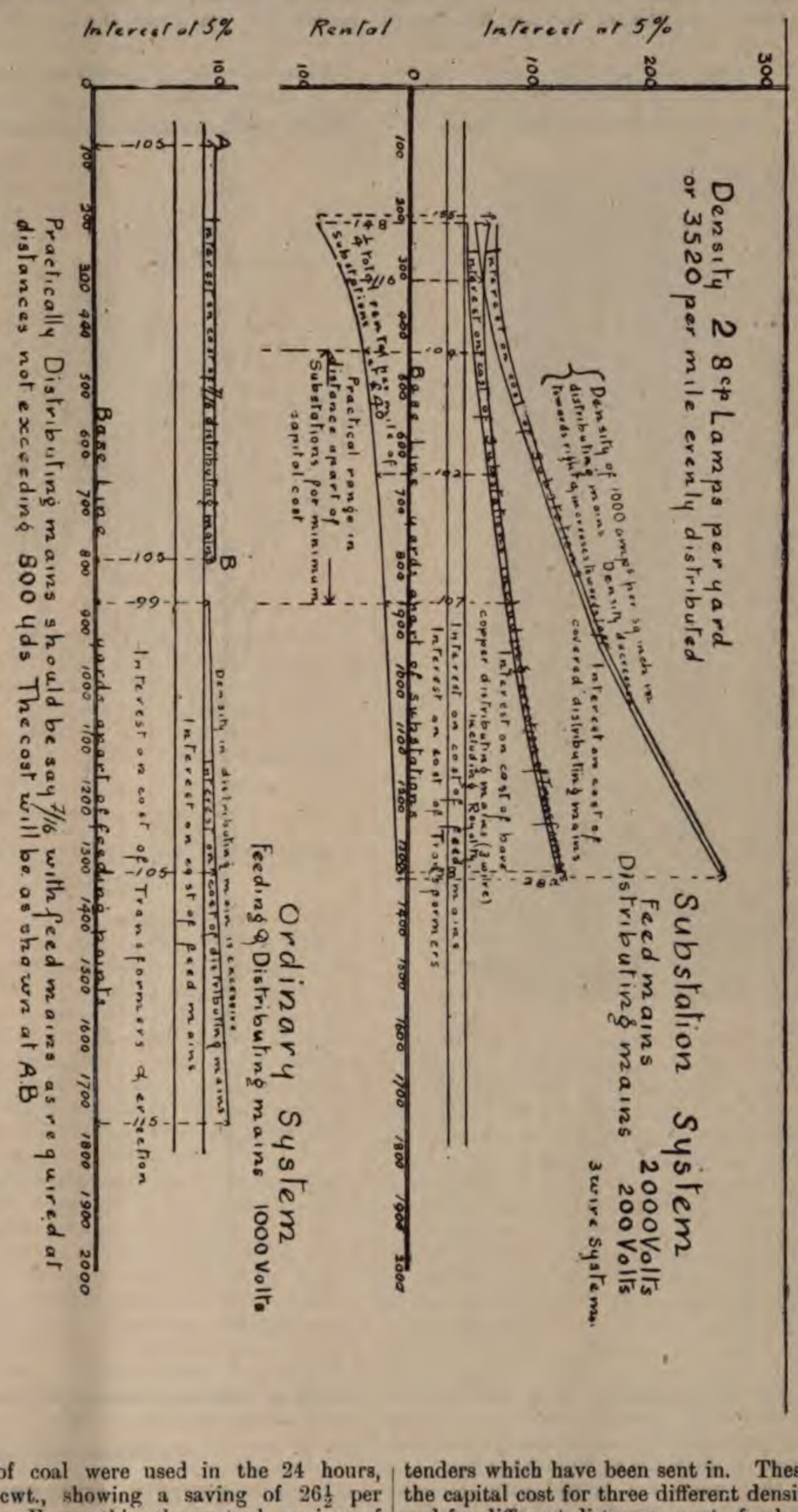


FIG. 5.—Relative Capital Cost of the Two Systems.

main situated at the mean distance of half a mile from the central station. The lines measured vertically downwards represent one quarter of the rental of sub-stations per mile, one quarter being taken because each sub-station feeds on an average in four directions. The farther apart the sub-stations are, the smaller annual rent of them will have to be apportioned to each mile of main.

The density shown in Fig. 4 is one 8-c.p. lamp per yard run, which is an average pioneering density in London. Figs. 5 and 6 represent densities of two and four lamps per yard respectively. These figures show that with a pioneering density the capital cost is about 5 per cent. dearer than that of the scattered transformer system, and that with all increased densities the capital cost is less.

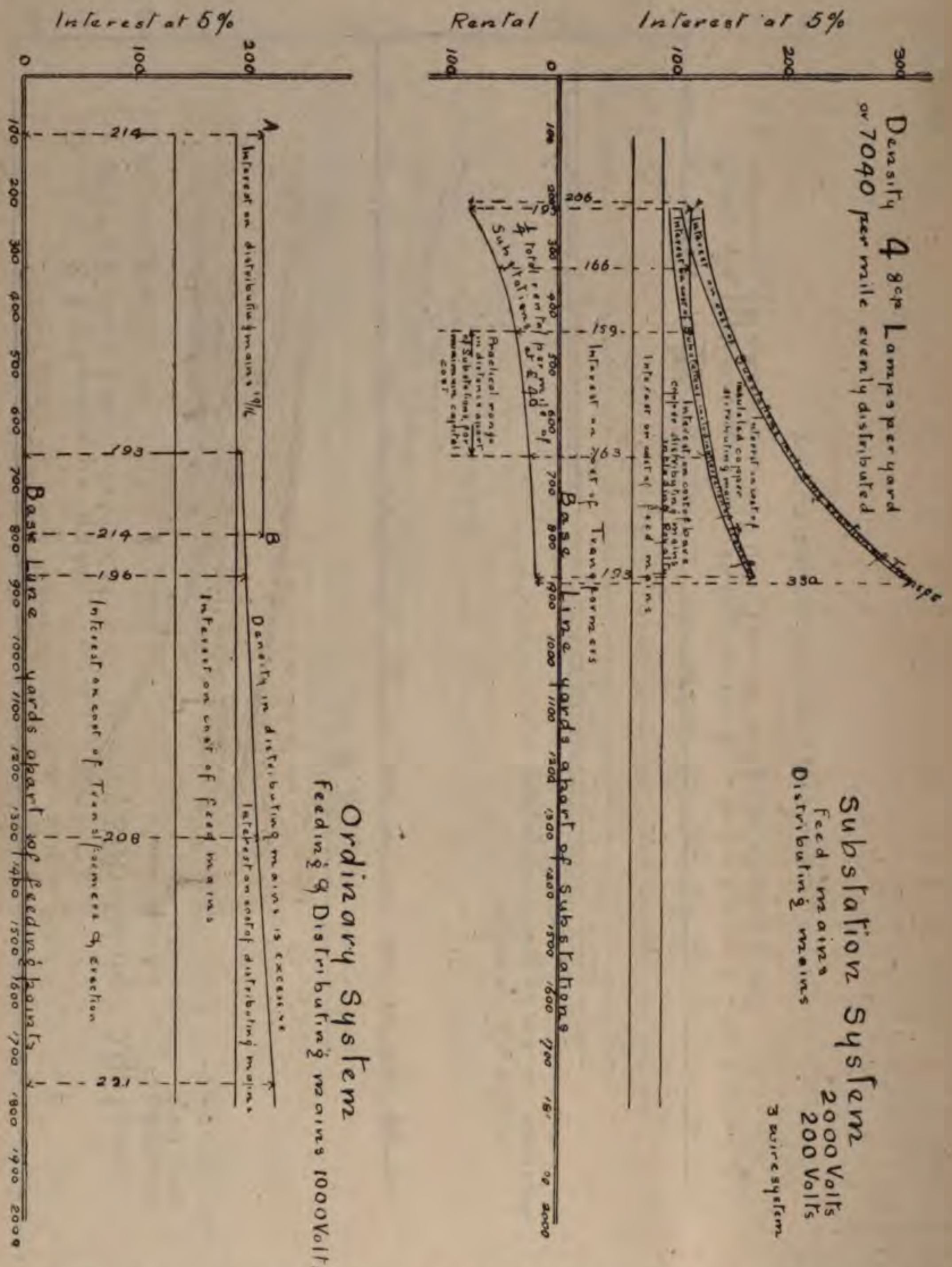


Fig. 6.—Relative Capital Cost of the Two Systems.

It will be seen that mains can be laid with the sub-stations half a mile apart for pioneering, and that by afterwards inserting intermediate sub-stations so that they may be quarter of a mile apart, the same mains will serve when the density of supply is quadrupled.

An objection has been made to the sub-station system that the owner of the cellar in the required position might find that his premises were necessary to the company, and therefore might ask an exorbitant rent. An examination of the curves shows that for a space of about 200 yards the upper and lower lines are nearly parallel, thus showing that the position of the sub-station can be shifted for 200 yards without sensibly increasing capital cost, and thus, instead of being tied to one cellar, we should have the choice of all the cellars available in 200 yards of street. This curve assumes the lights to be approximately evenly distributed, but it should be noticed that the existence of a large theatre or other public building at one point on the main would not affect the general calculations, as if such a building were large enough to disturb the calculations it would have a sub-station to itself.

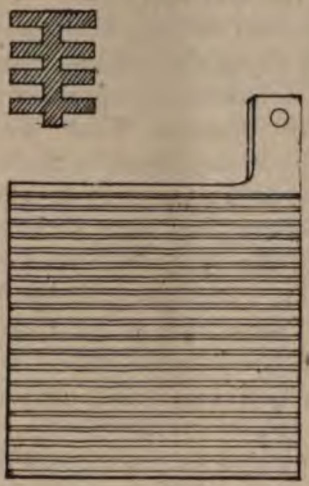
EPSTEIN ACCUMULATORS.

These batteries, which we have several times already mentioned, are now placed on the market by Messrs. Woodhouse and Rawson. Being formed by direct oxidation without the use of paste, they are entirely free from buckling or short-circuiting, and are claimed to be thoroughly reliable and long-lived.

The normal maximum discharge rate is 30 amperes per

Mark and No. of plates.	Weight of plates. lbs.	Acid. lbs.	Approximate external dimensions of box.			Weight of cell without acid. Approx. lbs.	Working rate.		Capacity. Amp.-hours.
			Length. Ins.	Width. Ins.	Height. Ins.		Charge. Amp.	Discharge. Amp.	
R 3	52	21	15	3½	17	60	1 to 30	1 to 30	120 to 150
,, 5	100	35	15	5½	17	120	1 ,, 60	1 ,, 60	240 ,, 300
,, 7	150	50	15	7½	17	175	1 ,, 90	1 ,, 90	360 ,, 450
,, 9	200	65	15	9½	17	230	1 ,, 120	1 ,, 120	480 ,, 600
,, 11	250	85	15	11½	17	285	1 ,, 150	1 ,, 150	600 ,, 750

positive plate, and for short periods this rate may safely be double. The capacity at the above rate of discharge is about 120 to 150 ampere-hours per positive plate; at half this rate the capacity is about 140 to 170 ampere-hours per positive plate. It will be noticed that the number of plates is small as compared with types by other makers. The containing boxes are made of glass, but can be specially made of other material if required. A special type for traction purposes, containing only a single plate, is in course of construction.



OIL AS AN INSULATOR FOR HIGH POTENTIALS.

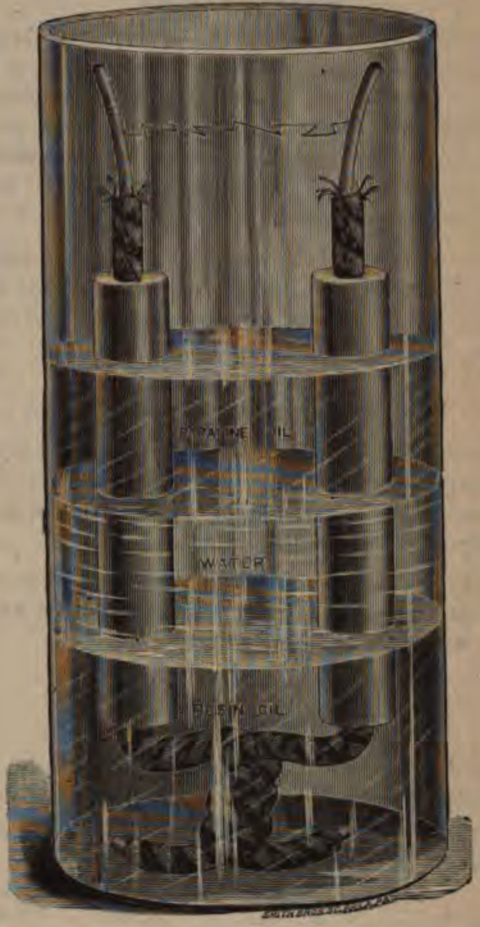
BY DAVID BROOKS.

There is much more written about the uses of oil for electrical purposes now than 10 years ago and not referred to, as then, as "oleaginous nonsense." Following up the note of mine in the preceding number of your journal, I immersed a small induction coil called "shocking machine" in oil and increased the inductive effects to such an extent that, with the plunger withdrawn, no one could bear the shock. I took it to two makers of those instruments and neither of them cared to make use of the improvement, because, by the use of the plunger, sufficient effect could be produced that any person desired to bear.

The effect was greatly increased when I discovered the properties of rosin oil. Although I had tested rosin oil earlier, I could not make near as much out of it as of paraffin oil, for the reason that ordinary rosin oil has about the same specific gravity as water and held water in suspension. But when you come to heat rosin oil and drive out the moisture its insulating properties are immensely increased, and the distillers are able to make an oil that is far heavier than water, or even heavier than sulphuric acid or any other liquid that I have ever experimented with, unless it be quicksilver.

The accompanying illustration shows an experiment that was exhibited at the Electrical Exhibition in Philadelphia, in 1884, nearly seven years since. It was labelled "The Electrical Pousse Café." It will be observed that when the wires are disconnected a cover can be placed over the jar to keep out the dust. I have that jar to this day, and have never been able to spark through the covering of the wires where they are twisted together, as shown, in the oil. The glass tubes prevent the spark from going through the water.

Now, I beg the reader to consider what advantage there is in having an insulation that is heavier than water and is not penetrated by it, or does not absorb it. How many hundreds of thousands of dollars' worth of guttapercha or indiarubber insulated conductors have failed within the past 10 years on account of the access of moisture to the conductor? Not immediately, but in time, the insulation disintegrates and decays, becomes spongy, or contains fissures. The first oil-insulated cable that was laid for practical use on my system was in London, in 1880, eleven years since. I then used paraffin oil and they had trouble in keeping it in the pipes. As soon as I found out the virtues of rosin oil I sent them a number of barrels of it, and since that was introduced they have had no trouble.



The London *Electrical Review* recently contained a series of articles entitled "Storms and Telegrams," by Messrs. Slingo and Brooker. They state as one of the advantages of the oil system that if the insulation is punctured by atmospheric electricity the oil soon closes up again the puncture, and that, to use their words, "it is self-sealing"; bringing that feature into consideration, in connection with the fact that the oil is heavier than water, it is worthy of note that, since the introduction of the rosin oil, of the many thousands miles of conductors that have been laid, for telephone, telegraph, and electric lighting purposes, not a single interruption has occurred to my knowledge.

I had forgotten entirely that I had obtained a patent for the use of oil in induction coils until I read the article on "Experiments on the Transmission of Power at Very High Potentials," and I do not know that I can say much more in its favour than is stated by Mr. C. E. L. Brown and by Prof. Thomson.

(*To be continued.*)

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VESTRIES, THE BOARD OF TRADE, AND ELECTRIC LIGHTING.

A very pretty question has arisen between the Chelsea Vestry and the Board of Trade, involving the jurisdiction of the Board of Trade to give powers to the London County Council which are concurrent with powers given by Act of Parliament to the Vestry. It is not quite determined what the powers of the Board of Trade may be, but whatever they may prove to be the Chelsea Vestry contend the Board has overstepped its powers. The immediate conflict hinges round the New Cadogan and Belgrave Electric Supply Company, and the Vestry have given notice of their intention to oppose the provisional order which the Board of Trade granted to that company. The Vestry object to the form of model order which has been adopted by the Board of Trade, and their objections have been communicated in a letter, signed by Mr. Moon (chairman of the Vestry's Electric Lighting Committee) and Mr. Higgens (surveyor to the Vestry), which has been addressed to the Secretary of the Board of Trade.

Briefly, the objections of the Vestry may be stated to be:

1. That Parliament in the Acts of 1882 and 1888 did not intend to give control to any other authority than the local authority. The Vestry submit that the Board of Trade has exceeded its jurisdiction in allowing an order to be granted which gives powers to the London County Council not in accordance with the Acts of 1882 and 1888.

2. That the concurrent jurisdiction of the Vestry and the County Council may lead to conflict between these two bodies, a state of affairs to be avoided if possible.

3. That the order provides for inspectors to be appointed by the County Council.

The Vestry submit that this provision is in direct contradiction to the provisions of section 6 (*e*) of the Act of 1882, which provides that the Vestry shall appoint the inspectors. They further submit that it is beyond the power of the Board of Trade to transfer this appointment to the County Council. It does seem absurd that under the Board of Trade the Vestry can now appoint an inspector over a company which supplies current to over 200 houses, but cannot appoint one over a company that supplies current to only 16 houses.

4. That the order allows the County Council to approve or disapprove of plans which relate to streets over which they have no control.

The Vestry therefore submit it should be at least left to Parliament to determine whether powers should be conferred upon the County Council or not, and that the Board of Trade should not grant an order which proposes to vary public general legislation, and which seems to go beyond the powers which the Board of Trade is authorised to exercise.

It may be taken for granted that this action of the Chelsea Vestry shows the determination which exists among the local authorities to resist any tampering with the powers that belong to them.

The Board of Trade is at times very insidious and very autocratic in its actions; and it is better to prevent a precedent rather than to permit it in the hope of getting it set aside hereafter.

EDISON'S LATEST.

This is the heading put to a Dalziel's telegram from Chicago. It purports to give the gist of a conversation with Edison to the effect that it is Edison's intention "to have ready for the World's Fair such a happy combination of photography and electricity as will enable a man to sit in his own parlour and behold depicted upon a curtain before him the forms of the players in an opera upon a distant stage, and to hear the voices of the singers. When the system is perfected, which I hope will be in time for the fair, the muscles of the singer's face, every glance of the eye, and each expression will be seen. Every colour in the performer's attire, too, will be exactly reproduced. Moreover, the spectator, seated by his own fireside, will see each person in the play move to his or her position in a natural way, just as though they were the very persons themselves." It is hardly necessary to suggest to our readers that they await further developments before giving credence to the belief that so great and successful a departure in a new direction has been made. The transmission of sound effect involves the use of ponderable matter, the transmission of light effect involves, in addition, the use of imponderable matter. The telegram given above hints at the use of photography and a lantern, so that the apparatus seems to be exceedingly complicated, and we venture to observe, notwithstanding all rumours to the contrary, photography in natural colours is not yet practical.

LAMPPOSTS FOR LONDON.

The chance is now open to the Brush Electrical Engineering Company to do something which shall redound to the credit of themselves and of London in the way of fine arc lamps and handsome lampposts. The arc lights we know they will make the best possible, but what will they do with the lampposts? Handsome and imposing and graceful design is not in itself in the way of the designers of electrical machinery, and to take, without further trouble, the first decent stock lamppost that offers is hardly the way to do credit to the first city in the world. Will the lampposts, we should like to know, be of the kind now experimentally erected? We may, if care is not taken by the directors of the new company, or the City authorities, have a gaunt, rigid "cast-iron" production variously streaked with criss-crosses and studded with jagged knobs up the post in the way of ornamentation, surmounted with a stiff, angular, four-square lantern—a hideous sight for men and gods. Or we may—let us hope, we shall—have an artistic, handsome, original production, worthy of the situation the lamps are to grace and the light they are to shed. The number of lampposts is considerable. The expense of a good design spread over this number cannot vastly increase the expenditure. The City of London Electric Light Company ought to offer a premium for a good design, and many architects and designers would only be too glad of this opportunity to distinguish themselves.

TRANSMISSION OF POWER BY ROTARY-PHASE ALTERNATE CURRENTS.*

BY M. VON DOLIVO-DOBROWOLSKY.

(Concluded from page 431.)

If there is no special need for the construction of motors for very high pressures, and when a low-pressure current (say, of 100 V) is already available, as, for instance, in town distributions of current, then it is advisable to use, especially for motors above 1 h.p., another type of motor, avoiding a second transformation. In working out this third type, what was principally aimed at was to obtain the highest possible efficiency, as the energy must be paid by the consumer according to wattmeter indications and at a considerable price. As Fig. 9 shows, the arrangement of the type "D T" is, in reality, a reversal of the motor in Fig. 2. The field magnet is rotatory and situated internally, whereas the closed-coil armature is stationary and situated externally. The field magnet generally receives a species of drum winding, by which arrangement the length of wire for producing the needful magnetism is reduced. The armature is at present usually not made solid, but built up of thin iron discs, and consequently the driving power is exercised only by the closed copper coil instead, as above, by Foucault currents of the iron as well, which are very difficult to be regulated and calculated. This type has, of course, the slight disadvantage that the revolving field magnet requires movable current connections, but as for this purpose simple smooth uninterrupted slide-rings are used, sparking is altogether obviated, and no attendance is required. Motors of this construction have the advantage that the iron mass of the electromagnet being less, its hysteresis is also much less than in an exterior electromagnet of the same iron cross-section and surface. The armature hysteresis is, on the other hand, of no importance, there being only as many armature pole changes as its actual number of revolutions remains less than the theoretical, (dependent upon the number of alternations).

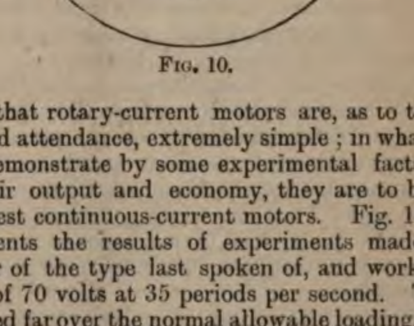

FIG. 10.

We see that rotary-current motors are, as to their construction and attendance, extremely simple; in what follows we shall demonstrate by some experimental facts that, as regards their output and economy, they are to be ranged above the best continuous-current motors. Fig. 10 graphically represents the results of experiments made with a 2-h.p. motor of the type last spoken of, and working with a pressure of 70 volts at 35 periods per second. The trial was extended far over the normal allowable loading, with the express purpose of determining how the machine would act when overloaded under abnormal circumstances.

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* Translated from the *Electrotechnische Zeitschrift*.

The motor has a weight of about 165 kg. (364lb.), and the result of several trials shows that after a long run at a load of 2 h.p. it becomes insignificantly heated, so that in the interest of durability and safety this load was stated as normal. That this limit of safety is sufficient follows from the fact that the motor employed in the above experiments was able to run for a short time with double this load. On the other hand, it results from the weight and the curve of efficiency, Fig. 21, that this limit was by no means relatively low.

The curve in Fig. 10 shows that the motor has not synchronous properties, as the number of its revolutions remains even with no load on a little below that calculated out of the number of alternations; on the other hand, we see that in increasing the load from 0 to its maximum the number of revolutions decreases by about 6 per cent., a quantity practically insignificant for a motor of 2 h.p., and exceeded by every continuous-current motor of the same output. Though in increasing the load the speed falls more rapidly than proportionally, it deserves, however, to be noticed that at an overloading of 100 per cent. the number of revolutions is still sufficiently high, and, therefore, the property of alternate-current motors of stopping when overloaded is entirely removed. On the same diagram we see that the useful work rises in proportion to the electrical energy consumed—namely, from 205 watts required at no load up to about 3 h.p., on which it falls off slightly. The output at the pulley has been traced on the diagram in watts, in order to facilitate its comparison with the electrical quantities.

The losses in the motor, as in every electric machine, are of three kinds:

1. Copper losses ($i^2 r$) in the field magnet and in the armature.

2. Magnetic losses: Hysteresis and Foucault currents.

3. Mechanical losses: Friction of air and bearings.

All these losses have been carefully and separately determined for this motor, and they are represented in Fig. 10 as function of watts consumed. We see from these curves that the copper losses gently rise with increase of loading, and endeavour to bend down the curve of the efficiency. The loss due to air and axle friction is almost constant, and the slight inclination of the corresponding curve towards the axis of abscissæ proceeds from the fall of the motor speed. Hysteresis and Foucault currents in the field magnet iron are also almost constant. They decrease towards the end of the curve only by some few per cent. The hysteresis of the stationary armature is, on the contrary, continually increasing, the number of pole changes in the armature being dependent, as above referred to, on the "slip" of the motor—*i.e.*, on the difference between the number of revolutions of the motor and that of lines of force. For clearness of realisation, the above losses have been added together and represented by a special curve.

From the ratio of the useful output to the power consumed follows the total efficiency of the motor, which is represented in Fig. 11. The abscissæ express the output at the pulley in watts, and, for clearness, the ordinates corresponding to 1, 2, 3, and 4 horse-power are drawn. We see from this curve that the efficiency already attains 75 per cent. at 1 h.p. (half load); it amounts to over 80 per cent. at the normal load = 2 h.p., and has its maximum = 81·4 per cent. at nearly 2·3 h.p. From the flatness of the curve we see that the range of economical working is very extensive, and that any overloading unavoidable in practical service, and harmless to the motor, if of short duration, has no disadvantageous influence upon the economy of

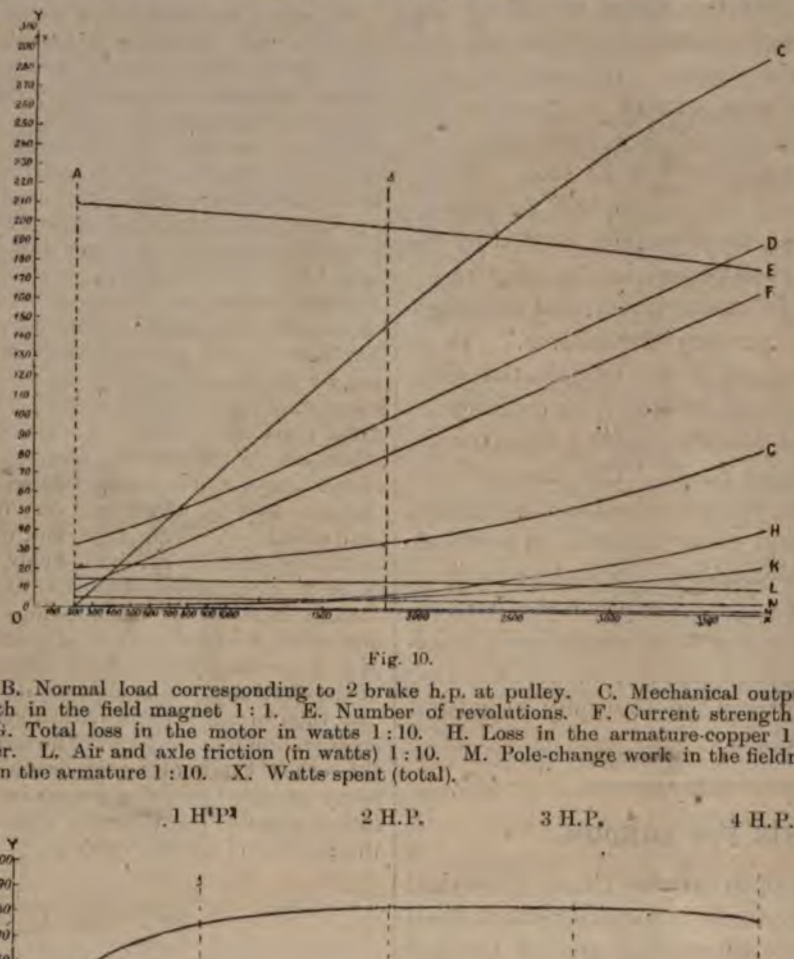


Fig. 10.

A. No load. B. Normal load corresponding to 2 brake h.p. at pulley. C. Mechanical output in watts 1 : 10. D. Current strength in the field magnet 1 : 1. E. Number of revolutions. F. Current strength in the armature (induced) 1 : 10. G. Total loss in the motor in watts 1 : 10. H. Loss in the armature-copper 1 : 10. K. Loss in field magnet copper. L. Air and axle friction (in watts) 1 : 10. M. Pole-change work in the fieldmagnet 1 : 10. N. Pole-change work in the armature 1 : 10. X. Watts spent (total).

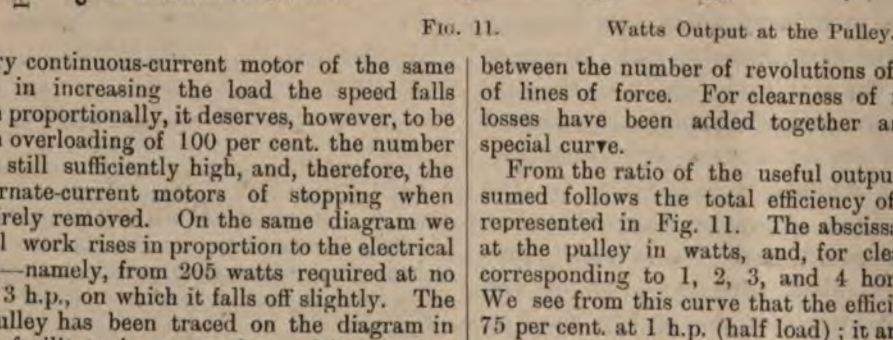


Fig. 11. Watts Output at the Pulley.

working. A comparison with continuous-current motors will distinctly show that rotary-current motors of the same size are far superior as regards output and efficiency.

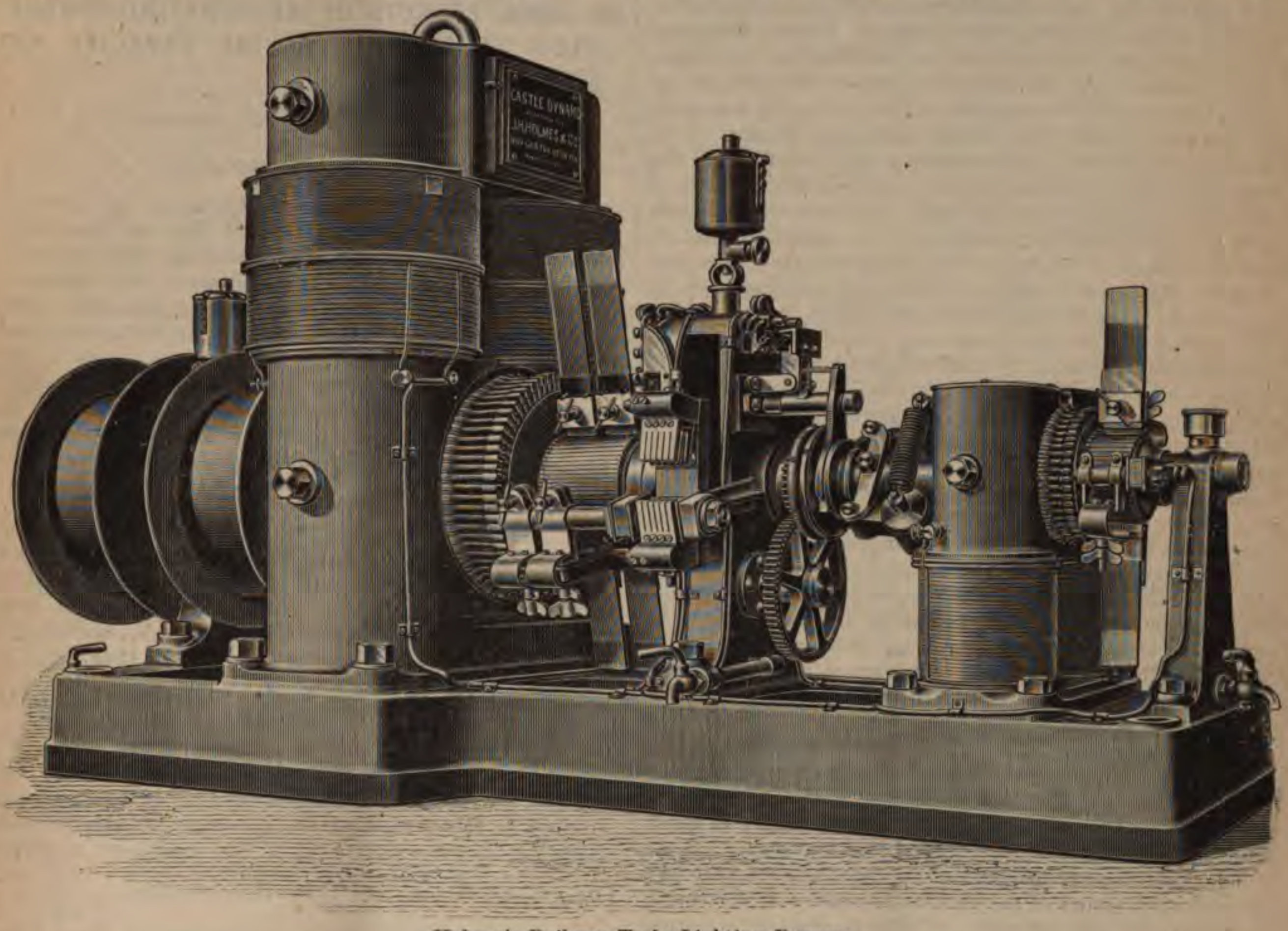
Further, there is to be expressly pointed out that rotary-current motors can start at whatever position with a very great tractive power, so that no loose pulleys or any couplings are required. The starting is effected simply by turning on the currents (in very small patterns), or by degrees by means of "starting resistances" in cases when sudden current impulses of great intensity are not desired, on account of their affecting the neighbourhood. These resistances enable the motor speed to be lowered at will, without any disadvantage to the tractive power. Though the efficiency is no longer as favourable as without resistances, still this possibility of regulation at starting and during the run affords an enormous advantage in comparison with alternate-current motors, which cannot be regulated, or are regulated but by fits and starts. The 2-h.p. motor above spoken of was tested relatively to its capability to start of itself when loaded, in the following manner. It was coupled direct with a continuous-current dynamo, the field of which was excited from an exterior source, which allowed the dynamo to be already loaded at the beginning of starting. In the circuit of the dynamo armature was inserted a resistance loading the motor at its full speed to more than double its normal load. The rotary current was then suddenly turned on, and the starting lasted 2-3 seconds. The reversal of the rotation of the motor, coupled with the dynamo, takes only about four seconds, of which the resistance of inertia offered by rotating masses is by no means small. The starting of the motor alone without any load, or any starting resistances, lasts a scarcely perceptible time, and goes on quite silently, so that in general its running can scarcely be heard, even when standing by its side.

In conclusion, we will point to a further advantageous property of rotary-current motors as against many other alternate-current motors—namely, that they possess a very small deviation of phase between current and pressure, so that the ratio of the energy actually absorbed to that seemingly consumed is nearly = 1; hence the leads do not need to be stouter than in the case of a continuous current of the same output. The power seemingly consumed at normal loading follows from the magnet current curve, Fig. 10, available for each of the three motor circuits and from the working pressure, and has the value

$$3\,(70\ \text{V} \times 9{\cdot}9\ \text{A}) = 2{,}079\ \text{watts.}$$

The power actually consumed, as shown by the curve, amounted to 1,830 watts, their ratio is therefore = 0·88. In increasing the load this ratio becomes far more favourable. The phase deviation between current and pressure being = 72 per cent. at no load, sinks to 28 per cent. at a load of 2 h.p., and even to 22 per cent. at a load of 3 h.p. Whether this ratio is still more favourable for larger motors cannot yet be stated, as the relative measurements have not yet been made.

As the present article aims first of all at drawing attention to the rotary current as a new means of transmission of power and at giving a general review of the system, certain particular features may seem to be not yet sufficiently examined, and the writer has, therefore, in view a series of articles upon different details. He hopes also that the transmission of power between Lauffen and Frankfort will give him the opportunity of bringing his system before a greater number of electrical engineers.



Holmes's Railway Train Lighting Dynamo.

J. H. HOLMES'S RAILWAY TRAIN LIGHTING DYNAMO.

The accompanying illustration represents an improved train-lighting dynamo, manufactured by Messrs. J. H. Holmes and Co., of Newcastle-upon-Tyne, and 17, Coleman-street, E.C. This apparatus has been employed by the Midland Railway Company, in connection with the electric lighting of their express trains. Mr. William Langdon, of Derby, explained its merits pretty fully in his paper read at the recent meeting of the Institution of Civil Engineers, It has also been supplied for French, German, and Russian railways.

The dynamo, which has been patented by Mr. J. H. Holmes, Assoc.M.Inst.C.E., is constructed with the object of maintaining a constant difference of potential at the terminals of the dynamo under a considerable variation of speed, and when driven in either direction It depends upon the following principles—namely, practically speaking, the E.M.F. of an ordinary separately-excited dynamo varies directly as the speed at which the armature revolves, so if the speed be increased, say, from 500 revolutions per minute to 1,000 per minute, the E.M.F. will be doubled. The E.M.F. varies also directly as the strength of the magnetic field, so that if the strength of field of a separately excited dynamo be reduced in the same proportion as the speed at which its armature revolves is increased, then the E.M.F. of the armature will remain practically constant.

To this end two dynamos are arranged in near proximity, having their two armatures upon the same shaft so as to revolve together, but influenced by separate magnetic fields. The one is the main generating machine, the other is for regulating the strength of the magnetic field of the generating armature. The magnets of the machine are separately excited from an external source such as a set of accumulators, and the magnets of the generating armature are provided with two distinct exciting circuits. One circuit is an ordinary high-resistance shunt circuit, and the other is of less resistance, and is coupled up to the source of current, so as to have the small regulating armature in series with it. The regulating armature is so coupled up that its E.M.F. opposes the E.M.F. of the regulating armature and external source of supply. The high-resistance shunt circuit is so proportioned that at the highest speed at which it is intended to run the generating armature, it, without the aid of the regulating circuit, will give a magnetic field of an intensity proper for the required E.M.F. in the generating armature. When thus driven the second exciting circuit ought to have no current passing through it, a result which is brought about by the E.M.F. of the regulating armature being, at its highest speed, equal and opposite to the external source of E.M.F. If, however, the speed falls, the E.M F. of the regulating armature is lessened in the same proportion, and being no longer equal to the external E.M.F., a current will be permitted to flow through the lesser or second exciting circuit of the magnets of the generating armature, thus increasing the intensity of the magnetic field to make up for reduction of speed, with the result of maintaining a practically uniform E.M.F. in the generating armature.

When the speed falls to the lowest limit, say half the highest rate of speed, the E.M.F. of the regulating armature will be half the E.M.F. of the external source of supply, so that it will be seen that it is necessary to calculate the proportions of the second exciting circuit of the generating armature magnets upon the basis of only half the electric pressure of the external source of E.M.F. being available, and the resistance of the regulating armature forming part of the circuit resistance. At the lowest speed, therefore, half the exciting power upon the generating armature magnets will be produced by one coil having the full difference of potential of the external source of E.M.F. at its terminals, and the other half by the second and lesser coil having half the difference of potential at its terminals, less, of course, the drop of potential due to the resistance of the regulating armature, which forms a portion of this circuit.

As arranged for use on railway trains, the armature is driven by belting from the axle of the guard's van, and a set of accumulators furnish the current for exciting the field of the field magnets. A centrifugal governor on the armature spindle automatically switches on the storage batteries for exciting the magnet coils of both the exciting and regulating machine as soon as the speed rises to the minimum speed at which the dynamo is intended to come into action, and it in like manner also switches off the current when the speed falls below the minimum speed. As the dynamo has to produce current when the train is running in either direction, the brushes which collect the current from the two armatures are made of wire gauze, and are placed radially to the commutators, and the "lead" being automatically altered to meet the direction of rotation. The connections to the armatures are at the same time changed, so as to keep the polarity of the dynamo terminals always uniform.

On the spindle carrying the armatures is also arranged a reversing switch, which is actuated by friction discs, which come into action when the spindle slows down, but which runs free on its attaining any degree of speed. The duty of this reversing switch is to ensure correct polarity of current.

Working in conjunction with the dynamo is an automatic cut-out such as is generally used in electric light installations having one, the highest resistance, coil connected to dynamo terminals, and the other, the low-resistance, coil in the main lighting circuit. The duty of this instrument is to cut the lighting circuit at all times except when a current of a sufficient E.M.F. is flowing to meet that arising from the accumulators employed throughout the train.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING, MEMBER.

(Continued from page 465.)

6. In his book on "Alternating Currents," p. 55 (second edition), Mr. Blakesley has treated by his geometrical methods the case examined above, with the object of showing that the employment of a condenser in this manner in combination with a pair of inductive circuits may under certain conditions cause the current in the remote, or shunt, circuit to be greater than the current in the circuit in connection with the machine; and he shows there that a similar criterion to the one given above applies also to the relative current strengths in the two sections—viz., that the current I_2 in section *b f* will be greater than the current I_1 in section *a b* if C is less than $\frac{2\,l}{r^2 + p^2 l^2}$.

Hence, generally, we have that the maximum or mean potential, V_1, at the terminals of the condenser will be less than, equal to, or greater than the maximum or mean potential at the terminals of the machine V_0, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,L}{R^2+p^2 L^2}$, in numerical value; and also that the maximum or average current strength in the remote, or shunt, section of the line will be less than, equal to, or greater than the maximum or mean current strength in the section of the line near to the machine, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,l}{r^2+p^2 l^2}$, in numerical value. Note that if R is measured in ohms and L in henrys, C must be measured in farads.

If we look again at the equation,

$$\left(\frac{V_0}{V_1}\right)^2 = (1 - C\,L\,p^2) + C^2\,R^2\,p^2,$$

and note what are the conditions under which V_1 will be greater than V_0, or the pressure at the condenser end greater than the pressure at the machine end of the line, we see that it depends upon whether the right-hand expression, when worked out numerically is a proper fraction. Since almost any capacity which occurs in practice is numerically represented by a very small fraction when the farad is the unit, if p^2 is not very great $C^2\,R^2\,p$ will nearly always in practice be a proper fraction when we insert values of C and R in farads and ohms. Hence the condition of rise of pressure will depend almost always on whether $C\,L\,p^2$ is numerically greater than 2 when C and L are measured in farads and henrys, and if C is very small either L or p must be very large to secure this result, and *vice versâ*. Hence, generally, if the inductance of the machine circuit is very large, a comparatively small capacity across its poles may give rise to a very great condenser effect; but if the inductance of the machine is small a very large capacity will be needed to bring about the increased pressure at the terminals of the condenser.

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* Paper read before the Institution of Electrical Engineers May 7, 1891.

Suppose, for instance, that a transformer is used to raise the pressure of an alternator, and that across the high-pressure terminals of the transformer is placed a condenser of capacity C. This may be either a condenser of the ordinary form, or a certain length of concentric cable insulated at the far end, and having a definite capacity. Let us suppose that the high-pressure circuit of the transformer has a great many turns of wire. The mean inductance of this high-pressure coil is then the L in our formula, its resistance is our R, and p^2 is $4\pi^2 n^2$, where n is the frequency of the alternator. To fix our ideas, let $n = 83 = 10{,}000$ alternations per minute, then $p^2 = 273{,}947$.

Let R = 10 ohms, and L = 200 henrys—values possible to be reached in practice—then, if C is measured in microfarads, we see that that $(1 - C L p^2)^2 + C^2 R^2 p^2$ becomes

$$\left(1 - \frac{C \times 273{,}947 \times 200}{10^6}\right)^2 + \frac{C^2\, 27{,}394{,}700}{10^{12}} = (1 - 55\,C)^2$$

$\pm \cdot 00003$ C, nearly.

If C is absolutely zero, the value of this quantity is unity. If C is equal to $\frac{1}{27}$ of a microfarad, this quantity is also, roughly, equal to unity. If C has any value between zero and $\frac{1}{27}$ of a microfarad—say, $\frac{1}{50}$ of a microfarad—then, since

$$\left(1 - \frac{55}{50}\right)^2 + \cdot 0003\,\frac{1}{50} = \cdot 01,$$

nearly, we see that the ratio of V_0^2 to V_1^2 will be 1 to 100, or V_1 will be ten times V_0. Hence it is obvious there is a narrow range of capacity within which the pressure at the condenser terminals may be enormously increased over that at the machine terminals; but if the capacity is altered so as to take it outside these critical limits, the so-called resonance effects will vanish.

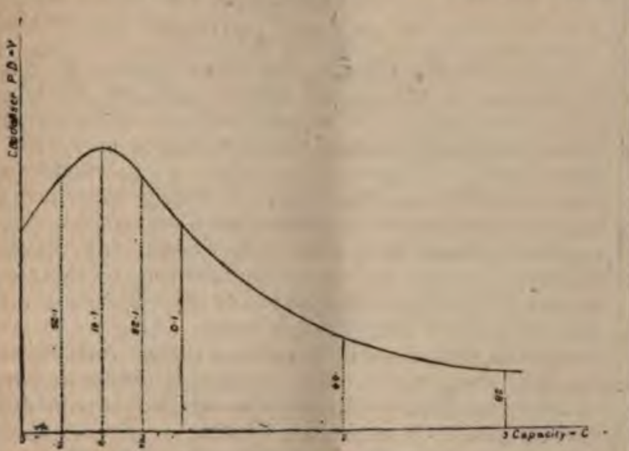
The best way to see how the value of V_1, or the condenser potential, varies with variation of the capacity, other quantities being constant, is to plot the equation,

$$V_1 = \frac{V_0}{\sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2}},$$

or—which comes to the same thing, and is simpler to plot—the equation,

$$y = \frac{1}{\sqrt{(1-x)^2 + x^2}}.$$

This has been done in Fig. 2, and a curve representing the variation of V_1 in terms of C, or of the condenser plate P.D. in terms of its capacity, supposed variable, is there drawn, on the assumption that V_0, L, R, and p^2 have certain constant values. We see that the curve ordinate has a maximum corresponding to a certain capacity, and that beyond that point increase in capacity continuously diminishes the condenser plate P.D.



Curve plotted from the equation, $y = \frac{1}{\sqrt{(1-x)^2 + x^2}}$,

or $V_1 = \frac{V_0}{\sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2}}$.

FIG. 2.

The condenser effect will be at a maximum when C and L have such magnitudes that $C L p^2$ is unity, and C has at the same time a small value. In this case V_1 may be hundreds or thousands of times greater than V_0. In testing condensers with alternating-current machines, it is very important not to have that particular critical relation between C, p, and L, or the capacity, frequency, and inductance of the machine, which will bring about the resonance effect, or else the testing process may be a destructive process as far as the condenser is concerned.

8. Quite similarly, we can show that if the capacity of the condenser is fixed, there is a certain range of inductance of the circuit of the alternator within which the resonance effect takes place. For example, let C = ·1 microfarad, as before, $p^2 = 273{,}947$, and R = 10 ohms, then for the ratio of V_0^2 to V_1^2 we have the value,

$$\left(1 - \frac{273{,}947\,L}{10^7}\right)^2 + \frac{273{,}947 \times 100}{10^8} = (1 - \cdot 027\,L)^2 + \cdot 27.$$

If L = 0, this ratio is greater than unity; if L = 74, the ratio is again greater than unity; but for values of L between 0 and 74, the ratio is less than unity. In other words, within these limits of the inductance the pressure at the poles of the condenser is raised.

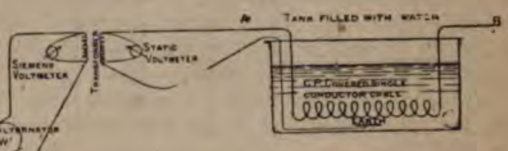


FIG. 3.—Arrangement of Alternator, Transformer, and Cable in Experiments made at Messrs. Siemens's Works.

The above theory is shown to be confirmed in its general character by the results of some highly interesting experiments, made more than a year ago (April 10, 1890) at the works of Messrs. Siemens Bros., which Mr. Alexander Siemens has sent to me. A Siemens W^1 alternator was kept running at a constant speed of 750 revolutions, and the exciting current was also kept constant. The current from this was sent into the thick-wire coil of a No. 2 transformer. The terminals of the fine-wire circuit were connected to various lengths of single-conductor cable, having guttapercha insulation and immersed in a tank; the cables being insulated at the far ends, and forming thus a condenser attached to the secondary of the transformer (see Fig. 3).

The pressure was measured at the terminals of the machine, and at the terminals of the transformer on the secondary, or condenser, side. The experiments consisted in varying the length of the cable used so as to vary the capacity, and in observing the pressure at the two sides of the transformer whilst the dynamo was kept running at constant speed and excitation. The results are embodied in the following series of interesting curves. The horizontal distances in the diagrams represent the various capacities of the open-circuit cables or condenser attached to the terminals of the secondary of the transformer. The vertical

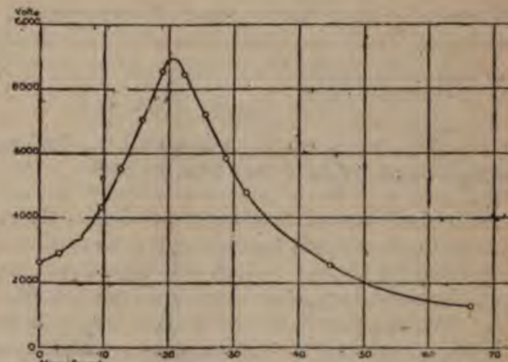


FIG. 4.—Curves showing Variation in Voltagein Secondary (high Voltage) Circuit by Varying Capacity in Secondary (high voltage) Circuit. Theexperimentshave been made with No. 2transformer, and current was obtained from W^1 machine, frequency being 100 revolutions. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

ordinates in Fig. 4 represent the observed P.D. of the two surfaces of this condenser—that is, the P.D. at the secondary terminals of the transformer.

It will be seen from Fig. 4 that when the capacity is zero this P.D. was 2,500 volts. As the length of cable was increased continuously this P.D. rose up to 8,500 volts, corresponding to a capacity of ·2 microfarad, and then fell again to 2,500 volts, at a capacity of ·45 microfarad. Hence, corresponding to a certain capacity—viz., ·2 microfarad—the pressure is multiplied about 3½ times, and there is a certain narrow range of capacity over which this exaltation of pressure takes place. At and beyond ·45 microfarad capacity, the presence of the condenser reduces the normal pressure continuously. The pressure on the primary side of the transformer is also increased, as shown in the curve given in Fig. 5, which represents a series of similar pressure observations taken on the primary side of the transformer. It will be seen that the same general effect takes place on the primary side. It will be seen how entirely these curves deduced from observation agree with the theory as illustrated by the curve in Fig. 2. The curves in Figs. 4 and 5 are generally similar, but, if superimposed, will be found to be not quite so. If the ratio of corresponding ordinates is set off so as to form a fresh curve, Fig. 6, this curve will give the variation of change ratio of the transformer corresponding to the various capacities, and we see that this change ratio is altered progressively from 1 : 43 to 1 : 57, as the capacity of the condenser on the secondary is changed from zero to ·65 microfarad. It is evident, therefore, that in applying transformers to test cable, such as concentric cable, which possesses sensible capacity, we must be on our guard against this alteration of the change ratio of the transformer, or else we may be misled as to the real pressure being applied to the cable.

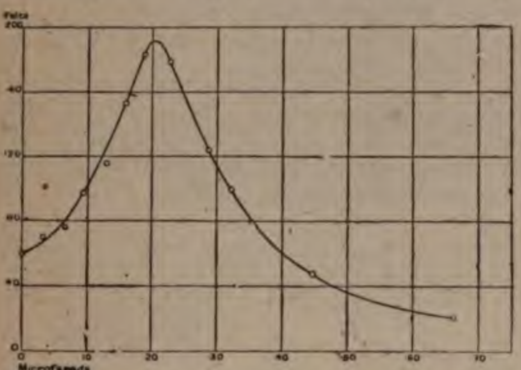


FIG. 5.—Curves showing Variation in Voltage in Primary (low voltage) Circuit by Varying Capacity in Secondary (high voltage) circuit. The experiments have been made with No. 2 transformer, and current was obtained from W¹ machine, frequency being 100 revolutions. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

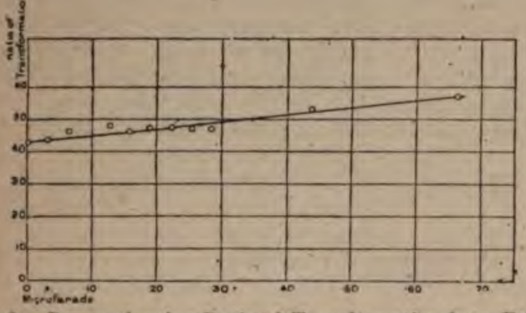


Fig. 6.—Curves showing Ratio of Transformation from Primary to Secondary Circuit, resulting from Figs. 1 and 2.

9. These considerations point out that in applying either transformers or alternators to circuits which have capacity, we must have regard to the fact that for certain critical values of the inductance and the capacity for giving frequencies, there may be a very considerable increase in the potential difference of the two sides of the condenser over and above that of the poles of the alternator or transformer when no condenser is present. Such effects have been noticed in practice of late. It has been frequently found that if a transformer which gives on its open secondary circuit a certain P.D. is applied to test the insulation of a length of concentric cable by connecting its terminals to the two conductors, the far ends of the cable being insulated, under some circumstances an increased P.D. is observed between the free ends of the cable over and above that at the terminals of the transformer when the cable is not connected to it. When transformers have been employed to test the insulation of armatures of high-pressure alternators, it has been noticed that under some circumstances large snapping sparks will jump off over air distances which could not possibly permit discharges at the actual P.D. of the secondary terminals of the transformer so used when unconnected with any such body having capacity.

In employing an alternator or transformer to test insulation between two opposed conductors, or in any way in which the opposed terminals gain capacity, it is necessary to be on the watch for this possible rise of pressure, and not to infer, because a transformer gives, say, 2,000 volts on open circuit between its poles when measured with an electrostatic voltmeter, that, therefore, this is the measure of the pressure which is being applied to a dielectric which forms the insulator of a condenser joined in across the poles of that transformer.

I am not at all sure that under some circumstances errors may not be committed in the mere use of an electrostatic voltmeter to measure P.D. between the poles of an alternator or a transformer, if that voltmeter happens to possess a certain capacity in relation to the inductance of the circuit in which it is joined in parallel.

(To be continued.)

BOMBAY.

The introduction of electric lighting in Bombay has been under consideration for some time past. It has been urged that the difficulties which Bombay has to guard against in the matter are the extremes of heat and moisture. During the heavy rainfall of the monsoon the ground becomes so saturated that insulation is difficult. Of course, electric cables are kept insulated in the sea; but the problem in Bombay is, says a daily paper, to find how an efficient system of insulation which will not add disproportionately to the cost of the plant. We fancy there are a good many manufacturers that would not mind tendering, but if the insulation offers such difficulties, why not try Brooks's oil system.

TENDERS.

BY SYDNEY F. WALKER.

In the following remarks the writer proposes to discuss the bearing of the tender system upon the working of engineering business. The question is one that notoriously bristles with difficulties, and it is therefore only with the view of calling the attention of others to the matter that the discussion is introduced. Probably everyone who tenders habitually for work has reason to complain of the expense to which he is often put without any chance of recouping himself. Every manufacturing or contracting engineer will tell you that he has to keep draughtsmen and clerks who never earn him a sixpence owing to the work entailed in getting out estimates and plans. Notwithstanding this, though, the tender system is about as fair all round as it is possible to make things in the commercial world if it is fairly worked.

It should not be forgotten that every firm who submit tenders in competition for work they hope to get, also require tenders from other firms for parts of their apparatus which they do not make, so that while they suffer from the cost of preparing estimates, they also benefit by being able to ask others to tender.

Take, for instance, an installation for electric light, and for pumping by electricity. If the firms who tender for the work make their own dynamos and fittings, they will rarely make their own pumps or their own engines, and hardly ever their own cables.

But it is one thing to submit a price for something that is a regular stock article of manufacture, and whose cost is therefore accurately known, and quite another thing to send a skilled man perhaps hundreds of miles to survey the work, possibly to advise how it had better be done, and afterwards to spend time and money preparing an estimate. In the one case the cost entailed may be only the clerk's time writing a letter and the postage, while in the other the expense may be very heavy.

Again, this cost would not be a serious matter if it only occurred occasionally, or if there was a fair probability that a certain proportion of orders would be secured. But in a great number of cases there is no such certainty, or even probability. Firms who do certain work are often put to the expense of preparing numerous tenders that there is not the slightest chance of their securing orders for.

In some cases buyers have determined beforehand to whom they will give their orders, and merely ask for other tenders as a check upon the firm they do business with.

If the buyer gives an occasional order to the other firms, of sufficient magnitude to enable them to recoup their expenses and have a trifle for profit, there is no great harm done; but, in many cases, there is no thought of such a thing—not the faintest idea that the buyer is under any obligation to those who prepare tenders for him. In his view it is sufficient recompense to be allowed to tender. In some mysterious manner the firm tendering will doubtless get paid by someone else. This kind of thing, of course, tends to correct itself, as firms get tired of tendering with no result; but in the writer's opinion the buyers who work upon the above lines would be better off in the end if they acted more fairly to all parties, and if they were to try and remember that other firms have to live and pay their expenses as well as themselves, or they must cease to be at their command.

Another unfair case is that where a consulting engineer draws the specification so that only firms using a certain kind of apparatus in which he is more or less directly interested, can compete with any chance of success. The consulting engineer easily reconciles this plan with his conscience and his duty to his employer. It is his duty to see that his employer has the very best, the most efficient apparatus, and his own has been designed from that very standpoint to be superior to all others. And as Coco would remark under similar circumstances: "If it was designed to be so, it is so; and if it is so, why not act upon the fact."

This kind of thing also tends to correct itself, as firms who do not care to supply the apparatus that a particular engineer believes in, or who cannot supply it at the competitive price that will rule, do not go to the expense of tendering where this engineer specifies.

But, perhaps, the most unfair case of all, and the one the writer had principally in his mind when he commenced this article, is that where the apparently would-be buyer doesn't intend to buy at all. He merely wishes to know the cost, and instead of paying someone to advise him on the subject, makes use of the tender system to get the information without paying for it. There are cases, of course, where a manager, or the proprietor of works, say, believes from information previously obtained that certain work can be carried out at a much lower cost than eventually proves to be the figure; or where a manager endeavours to induce his employer to spend money for a certain purpose, and with that view has tenders got out which are not accepted. But in either of these cases it would be much fairer and more considerate either to employ some qualified man to work out the cost, and to pay him for it, before asking others to go to expense that it is only problematical if they will get paid for, anyone of them; or to ask some firm with whom the works are doing business regularly to furnish an approximate estimate, such as any engineering firm can always do at no appreciable cost from figures they have at their disposal. In too many instances, however, managers and proprietors of works think it sharp to work in this way. They mistake this sharpness for the foresight which is another name for shrewdness. In many instances, too, managers and proprietors of works think because they have an order to place, or that may be placed, they have the right to practically levy toll upon everyone who might, under certain circumstances, be favoured with that order.

A broad distinction should, of course, be made here between the case of manufacturers or contractors seeking business, and that of buyers seeking to know the cost of laying down plant.

If the representative of a firm calls at a works, for instance, with the object of inducing the proprietors to adopt certain improvements in their appliances, it is only fair that the latter should ask the former to state the cost. If, also, a firm learns that a certain contract is to be given out, and ask to be allowed to tender, they cannot complain at having to pay the cost of preparing a tender, even though the contract may never be given out. But these cases are very different from those where the proprietor of the works takes the initiative. In the one case, the would-be contractor is acting for his own benefit, as he believes, and at his own initiative. If he spends money on a tender it is of his own free will. In the other case he is asked to spend money for the benefit of another, and without the chance of a return.

With a view to a solution of some of the difficulties of this troublesome subject, the writer suggests, for the consideration of engineering firms, that all tenders involving much expense should be charged for; the charge to be deducted from the amount of the contract by the successful competitor. Thus, taking the case of tenders costing on the average £50 each to prepare, the buyer should select certain firms to tender who would name their charges for preparing estimates, and who would be paid for them either in the contract price, or directly for the tender. If any other firm that had not been selected wished to tender, they would of course pay their own expenses. If the contract was not given out, no one would be the loser. Each competitor would include the £50, or whatever their charge was, in the amount of his contract price, so that the successful one would really receive the amount of his tender, less £50, for his work, and be paid for preparing his tender just the same as the others.

The buyer would have to reckon on paying the amount of the accepted tender, plus the charges of the selected firms for preparing tenders. On the face of this plan it looks as if the buyer would pay more for his work than he does at present, but a little consideration will show that he would probably pay less. Under the present system, the cost of preparing all the tenders that are sent in by any firm is borne by the profit on those they secure, so that a proportion of the cost of what may be termed the bogus tenders are paid by each *bonâ fide* purchaser. If the above plan were adopted, bogus tenders would either cease or be paid for, so that the purchaser of each plant would only pay the cost of preparing his own estimates, and not that of others in addition.

The writer is aware that the cases of tenders for public bodies are not so easily dealt with on these lines. Public bodies spending public money must show no favour, and selection would be favour. Probably this difficulty could be overcome by a system of registration. Those firms within a certain radius who showed proof of their ability to execute certain orders having the right to be registered free of charge, and to be paid for tendering when required. Those firms outside the pale of the district who wished to tender for the work at the disposal of the local authority, to be registered on payment of an annual fee, which should cover the cost of registration and the allowance for tenders. It should of course be within the power of the local authority to place the name of any firm of eminence, whom it would be to the advantage of the ratepayers to secure tenders from, on the registration list free of charge; or to ask them for tenders, paying their charges.

The above system is not easy of introduction, but it would save much unnecessary expense, and many angry thoughts.

LEGAL INTELLIGENCE.

IN RE JABLOCHKOFF'S PATENT (ELECTRIC LIGHT).

The petitions of the Electrical Engineering Corporation, Limited, for the confirmation and extension of Jablochkoff's patent (electric light), dated May 22, 1877, came before the Judicial Committee of the Privy Council on Wednesday.

Mr. R. Wallace and Mr. Renton (with whom was Mr. Moulton, Q.C.) appeared in support of the petitions; the Attorney-General and Mr. Sutton for the Crown.

The **Attorney-General** said it was his duty to point out that there was an objection to the petitions. If their lordships would look at the petition for extension they would find it stated that M. Jablochkoff also obtained grants of letters patent for his invention in France, Belgium, Germany, Italy, and Canada. On looking through the accounts he (the Attorney-General) found that some of those patents were taken out prior to the English patent. A patent was taken out in France on November 30, 1876, which was stated to be still in force and which expired, he was informed, in November of this year. The Belgian patent was taken out before the English patent—namely, on February 6th, 1877, and expired on October 8th, 1888. He (the Attorney-General) should have to refer to two others—one taken out on August 14th, 1877, in Germany, which lapsed in 1883, and another taken out on May 25th, 1877, three days after the English patent, which also lapsed in 1883; but he did not refer to them then. They were proceeding under statutes which were repealed in 1883 by virtue of the saving clause. If their lordships would look at the 25th section of the Patent Law Amendment Act, 1852, they would see that if an earlier patent was taken out in a foreign country and was allowed to expire, the English patent died at the same period. Unless his learned friends had some answer, that was a fatal objection in so far as the Belgian patent was concerned. The Attorney-General went on to refer to the Act of 1883, the Patent Law Amendment Act, 1852, and the Act 5 and 6, William IV., c. 83, and quoted authorities in support of his contention.

Mr. Wallace, on the part of the petitioners, argued that section 25 of the Patent Law Amendment Act, 1852, did not apply to this case, and that the petitioners were entitled to rely on the Act 5 nd 6 William IV., c. 83.

Lord Watson, in delivering judgment, said there were two separate applications with regard to this patent. In one their lordships were invited to recommend that the patent be confirmed in the terms of the second section of the Act 5 and 6 William IV., c. 83, and in the other to recommend that a prolongation of the patent be granted on such terms as might seem to them to be just. The English patent bore date May, 1877, but in the same year, on a previous date, February 6, 1877, the same invention was secured to the patentee in Belgium, and that right and privilege was declared to have lapsed by Royal decree of Oct. 8, 1888. It was conceded in argument by the petitioners that no application for confirmation of the patent could be made under the Act of 1883, and that statute abolished the Act of William which had already been referred to. But the Board was still in a position to entertain a petition for confirmation by virtue of the provisions of the 113th section of the statute, which saved the operation of the Act in so far as it related to a certain extent, which it might be necessary afterwards to deal with, in so far as it related to patents which were in force at the time when the statute of 1883 became law. If the Act of William stood alone the case of the petitioners would be comparatively plain, but the powers of confirmation which were conferred by that statute were qualified by the Patent Act of 1852, the 25th section of which enacted that in the case of an English patent, where a previous patent for the same invention had been taken out in a foreign country, the patent should cease and be void immediately on the expiration or other determination of the term during which the patent for the like privilege was obtained in such foreign country. If that qualification still applied to the patent right of the petitioner there was an end of his case; because his patent lapsed in 1888 along with the Belgian right, in terms of the statute. But the argument which had been addressed to their lordships had been to this effect—that, whilst section 25 of the Act of 1852 was wholly repealed in so far as regarded his patent, section 2 of the Act of 5 and 6 William IV. was kept alive in his favour. Now, that was founded on the provisions of sub-section 1 of section 113 of the Act of 1883, which appeared to their lordships, upon consideration, to be fatal to the contention which had been addressed to them. The saving clause in favour of patents in force at the date of the statute was in these terms: "This repeal of enactments shall not affect the past operation of any of those enactments, or any patent granted or acquired, or application pending, or appointment made, or compensation granted, or order or direction made or given, or right, privilege, obligation, or liability acquired, accrued, or incurred, or anything duly done or suffered under or by any of those enactments before or at the commencement of this Act." Now, it appeared to their lordships that at the date when the statute of 1883 passed there were incidental to the right of the patentee or the assigns in possession of the patent before them, first a right to confirmation should it be necessary, under the Act of William, but, in the second place, a liability in their right to be determined in the event of the lapse of the Belgian patent. These were a right and a liability which had arisen and formed part of the law of the patent at that date, and it certainly did appear to their lordships that, looking at the language employed by the Legislature, which saved all obligations and all liabilities attached and incidental to a patent—as well as all rights which had arisen to the patentee—it was impossible for them to infer that the Legislature meant to retain to patentees whose rights were older than the statute, a right to confirmation without the corresponding qualification which was introduced by the legislation of 1852; and, therefore, it appeared to them that the petitioners here could not appeal to the provisions of the Act 5 and 6 William IV., without submitting at the same time to the qualification of the statutory right introduced by the Patent Act of 1852, and, therefore, the application must be dismissed. There remained the petition for extension of the patent, which might be very shortly dealt with. As regarded that application the petitioners were in this dilemma. If it be represented as a petition presented under the terms of the recent Act the answer was conclusive that the statute had not been complied with, because it was not presented more than six months before the natural currency of the patent came to a close. The other alternative was that it was an application under the old law, and if it was viewed in that aspect the provisions of section 25 of the Patent Act, 1852, were as fatal to the power of this Board to deal with the matter of extension as those provisions were fatal in the other case of an application for confirmation; and, therefore, this petition also must stand dismissed.—*Times.*

COMPANIES' MEETINGS.

CHELSEA ELECTRICITY SUPPLY COMPANY, LIMITED.

Directors: J. Irving Courtenay, Esq., chairman; Major-General Webber, C.B. (retired R.E.), deputy chairman; Nugent Daniell, Esq.; Emile Garcke, Esq.; Sir George Prescott, Bart. Secretary: S. J. Cluer. Solicitors: Sydney Morse, Esq.; Messrs. Renshaw. Auditors: Messrs. Cooper Brothers and Co.

Report of Directors for the year ending December 31, 1890, presented to the shareholders at the general meeting on Thursday last.

The accounts are not issued in Board of Trade form, because that course would involve two separate balance-sheets (one for Chelsea and one for Kensington), which would be confusing to the shareholders. This is the subject of correspondence with the Board of Trade, and, when the matter is settled, the accounts will at once be put into such form as that Department may require. The steady progress of the business during the year is very satisfactory. On 31st December, 1889, 93 customers, or an equivalent of 8,730 lights of 8 c.p., were being supplied; while on 31st December, 1890, there were on the books 252 customers, with lights installed equivalent to nearly 20,000 lamps, of 8 c.p. The Company has received for current sold and meter rents in 1890 the sum of £6,067. 6s. 10d., and after deducting all working expenses, there remains a gross profit of £542. 19s. 5d. The consumption of fuel in the year 1890 has been excessive; but this is believed not to be due to any defects in the Chelsea system, and measures have been taken which it is hoped will prevent its continuance. The rate at which the revenue has increased is best exemplified by comparing the two heaviest quarters of the year. In March quarter the receipts for current supplied and meter rents amounted to £1,275. 12s. 3d., and in December quarter to £2,872. 17s. 6d. This affords an indication of the rate of increase of revenue in 1891; and, as the profits should be more than proportionately augmented, the prospects for the current year are favourable. Under the authority given at the last general meeting, the Directors resolved to issue £20,000 of 6 per cent. debentures, the whole of which has been subscribed. This has enabled the Directors to repay the loan from its bankers, and to complete the extensions in hand last year, including new mains and the new storage station in Pavilion-road. In view of the further extensions necessary to occupy the areas within the Company's districts, the Directors have decided, in lieu of issuing any further debentures at present, to recommend an issue of preference shares, and with this object a resolution will be proposed at the general meeting of the Company. The completion of the plant in accordance with the original plan of the central station in Draycott-place is in progress, and when the work contemplated for the year has been done the stations will be capable of earning over £100 during average lighting hours in one day. The experience gained by the Company shows that under the varying conditions of demand throughout the year in this district this earning capacity may be estimated to yield a gross revenue of about £16,000 per annum. After paying all outgoings, including the cost of upholding the plant, and interest on debentures, the balance should afford satisfactory dividends on the share capital. The mains, consisting of Callender's bitumen cable, of which about 20 miles have been placed underground, are regularly tested, and the results continue to be most satisfactory on all the cables, including many which have been underground for two years. None have had to be renewed on account of defects. The accumulators are all in working order. Those at Clabon-mews storage station, which have been longest in use—*i.e.*, for two years—are in excellent condition, and it has not as yet been necessary to replace any of the plates. The Directors have not dealt with depreciation in these accounts; but care has been taken to keep up all the plant to its original working efficiency. The storage batteries, which constitute a very large proportion of the plant, are under entirely new conditions as regards their working and supervision, and, until experience shows what provision is necessary, a renewals fund will be maintained out of the profits, in order to make provision for exceptional outlay in any one year. The Directors have to report the retirement of Lord Thurlow from the Board of the Company, and the election of Mr. Emile Garcke (managing director of the Brush Electrical Engineering Company, Limited) to fill the vacancy, subject to the confirmation of the shareholders. Mr. J. Irving Courtenay has been elected chairman of the Company, and Major-General Webber, C.B., deputy-chairman, while still retaining the post of managing director. The retiring Directors are Mr. J. Irving Courtenay and Sir George Prescott, Bart., who, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co., also offer themselves for re-election.

BALANCE-SHEET, DECEMBER 31, 1890.

Dr.	£ s. d.	£ s. d.
Share capital—		
Authorised	100,500 0 0	
7,460 shares of £5 each, fully paid up	37,300 0 0	
333 founders' shares of £1 each ...	330 0 0	
Total share capital issued		37,633 0 0
1,648 shares of £5 each fully paid up, being the maximum number of shares which may have to be issued to contractors in payment plant	8,240 0 0	
167 founders' shares of £1 each, which may have to be issued under agreement for supply of plant	167 0 0	
		8,407 0 0
Debentures secured on the property and undertaking of the Company repayable 29th September, 1895, with interest at 6 per cent. per annum.		
Authorised	50,000 0 0	
Subscribed	15,600 0 0	
Less amount receivable in 1891 ...	250 0 0	
		15,350 0 0
Note.—The remainder of the first issue of £20,000 has since been subscribed.		
Créditors—Amounts payable in cash to contracting companies for plant, and sundry other creditors		3,986 10 7
Balance		67 3 7
		£65,443 14 2

Cr.	£ s. d.	£ s. d.
Outlay on capital account—viz.:		
Buildings, as per last balance-sheet	9,045 14 5	
Additions, 1890	126 19 0	
Plant, as per last balance-sheet	27,733 13 6	
Additions, 1890	14,660 10 6	
Founders' shares, agreed to be issued as *per contra*	167 0 0	
Office furniture	140 19 0	
		51,874 17 2
Stores on hand		732 11 2
Debtors—Sundry debtors	3,201 18 7	
Suspense	510 1 6	
		3,712 0 1
Preliminary, preparatory, and experimental work and preliminary expenses, as per last balance-sheet	5,398 8 5	
Additional in 1890	625 9 3	
Commission and expenses of debenture issue	1,031 1 6	
		7,054 19 2
Cash at bankers	2,035 11 11	
Cash on hand	33 14 8	
		2,069 6 7
		£65,443 14 2

PROFIT AND LOSS ACCOUNT, YEAR ENDING DEC. 31, 1890.

Dr.	£ s. d.	£ s. d.
Coal, water, oil, wages of men, and other expenses of running	3,143 19 11	
General charges—		
Expenses of collecting accounts, postages, stationery, travelling, canvassing, and general office expenses	507 16 1	
Directors' fees	542 0 0	
Salaries	657 19 8	
Insurance	54 6 4	
Rates and taxes	120 17 5	
Rent	246 12 6	
Legal expenses	9 14 10	
		5,283 6 9
Renewals and maintenance of plant and buildings...		253 6 3
		5,536 13 0
Balance, being gross profit on the year's working ...		542 19 5
		£6,079 12 5

Cr.	£ s. d.
Revenue: Current sold, and small balances on account for connecting houses, meter rent, etc. ...	6,067 6 10
Interest on deposits	11 13 1
Transfer fees	0 12 6
	£6,079 12 5
Interest on debentures	£530 5 7
Suspense item of last year paid off	125 0 0
Balance carried to balance-sheet	67 3 7
	£722 9 2
Balance brought down	£542 19 5
Balance from last year	179 9 9
	£722 9 2

The ordinary general meeting of this Company was held on Thursday at the offices, Draycott-place, Sloane-square, Mr. J. Irving Courtenay, chairman, presiding.

The report and accounts (given above) having been taken as read,

The **Chairman** said: Gentlemen, when we met last year the profit and loss account presented to you was for one quarter of the year only, and that the quarter of heaviest demand. There was then shown a small balance to the good, but no Directors' fees had been paid. The amount received for current sold during 1890 was £6,067. 6s. 10d., and the gross profit shown in the accounts before you is £542. 19s. 5d. I may mention that the receipts for the March quarter in this year amounted to £3,275, but you will bear in mind that although we are now supplying current to more than 22,000 lamps, as against 10,000 this time last year, the increasing revenue in respect of these lamps was only even partially felt in the last quarter of the year 1890, and, moreover, the profit on that year's work has been made in spite of most disadvantageous circumstances, which I will now proceed to deal with. I allude to the question of the heavy consumption of coal mentioned in the report. I regret to say that the consumption during the year has been excessive, but I am glad at the same time to be able to inform you that the unceasing attention to the subject on the part of the management has resulted in the certainty of a reduction of the cost of producing the current as soon as the rearrangement of plant, now in hand, is complete. As the subject is still under discussion it is not permissible for me at the present moment to say where, in our opinion, the fault lies, but I sincerely hope that an amicable settlement of the difference will be arrived at. There is another point I must touch upon, because it has been the subject of some misrepresentations. Owing to non-delivery of machines, which were ordered early last year to provide for the winter supply, we were compelled on a few occasions in December, when a heavy drain came upon us through continued foggy weather, to shut off our supply of current for a few hours only in the daytime. Some of the plant having shortly after arrived, the constant supply was resumed on the 24th December, and maintained throughout the remainder of an exceptionally foggy winter. Now, unfortunate as this undoubtedly was, it still showed the advantages of the storage system; for instead of stopping the supply suddenly, as might be the case without storage, we were able to give a full day's notice that we should cease supply for a few hours in the daytime, and thus prevented serious inconvenience to our customers. We may congratulate ourselves that we have still the record of not having once stopped supply of current during the hours when light is ordinarily required, and I may also here add that our customers continue to express their entire satisfaction. You will find in the profit and loss account an amount of £253. 6s. 3d. for maintenance of plant. This is made up of small repairs to the different kinds of generating plant, instruments, tools, and about £50 in wages to men cleaning out accumulator cells. No expenditure was incurred in 1890 in replacing the E.P.S. storage battery plates, and up to the present day only one set out of 1,918 sets has had to be replaced, and that at a trifling cost. Now it must be borne in mind that the replacing of a set of plates is not merely maintenance, as in the case of repairs to a steam engine, but is a complete renewal of the cell, as the other parts for all practical purposes suffer no deterioration. The mains of the Callender Company have also fulfilled our expectations, and have not cost us anything for the repairs of cables. Some of the cables have been underground for over two years, and from tests taken periodically it is found that they are still in perfectly good condition. The E.P.S. accumulators are for the first time being used in sub-stations, under the direct supervision of our engineer, and so well have they performed their duty that it is difficult, even now, to settle what is a proper amount to set aside for their depreciation. It is intended, however, as stated in the report, to maintain a renewal fund out of profits, in order to provide for exceptional outlay in any one year. You will have noticed a printer's error in one of the figures of the balance-sheet, where the figure 9 appears instead of the figure 6. It should be 1,648 shares, and not 1,948 shares. It does not affect the money column. I now come to the present state of the business and its prospects. You will see by the balance-sheet that the plant has been increased by the amount of £14,660. 10s. 6d. The mains and the generating and storage plant have all had a share in this increase, but the greater part of it is to be found in the extensions of mains, and the erection of a new storage station in Pavilion-road. These additions, together with the plant ordered this year, will enable us to supply sufficient power for about 36,000 8-c.p. lamps installed, which, at the rate of 9s. per lamp installed, would represent a gross income of £16,000 per annum; but this increase would involve the extension of our mains as found to be necessary. Nine shillings per 8-c.p. lamp installed is the figure upon which our experience shows it is prudent to place our estimate of income. I am aware that this is a somewhat lower yield per lamp than that of companies in whose area of supply theatres, hotels, clubs, and shops are numerous, but the shops in Chelsea are now also coming on our list of customers. I think, however, it will be found in practice that the above figure fairly represents the yield per 8-c.p. lamp in domestic lighting, which is mainly our lighting in Chelsea and Kensington. Our district is an excellent one. There is no part of the metropolis where rebuilding is more continually going on, and very few houses indeed in this neighbourhood, as you are aware, are built without being wired for the electric light.

We have had added to our area of supply by the Board of Trade a very large portion of the parish of Chelsea, containing about 4,500 houses, including several localities favourable to the development of the business. I do not, however, wish to put before you a too sanguine view of our prospects. I have therefore had a careful estimate made of the probable increase during the year in the number of lamps to be supplied, and the result of enquiry points to our reaching a total of 32,000 lamps installed, provided we make the extensions of mains referred to. It is a matter of satisfaction that during a year of financial tightness, and even panic, we have been able to place all the debentures we offered—viz., £20,000—at a moderate cost. The money thus obtained has been carefully dealt with in the most economical manner, and by means of the new plant already obtained, and that on order, we can confidently look forward to a considerable economy in the working during the latter half of the present year. As has been mentioned in the Directors' report, it will be necessary to provide funds for the extension of the mains and for additional plant to meet the increase in the Company's business, and after full consideration the Directors have resolved to recommend the issue of preference shares bearing 6 per cent. interest, and for the present to defer any further issue of debentures. We propose to take power to convert £30,000 of the unissued ordinary share capital into preference shares. This fresh capital will be called up gradually as required. When this expenditure has been made the total issued capital of the Company, including debentures, will be about £92,000, or, in other words, the total capital outlay of the Company, including the cost of all stations, cables, and plant, will be, say, £2. 12s. per lamp fixed. These figures will compare favourably with those of other companies, especially when it is remembered that our conduits have a carrying capacity for double the number of lamps I have mentioned. I am prepared to give any further information that may be required, subject to the remarks made at the beginning of my speech. I beg to move the adoption of the Directors' report and statement of accounts.

This was seconded by **General Webber** (deputy chairman), and carried unanimously.

The re-election of the retiring Directors (Mr. Irving Courtenay and Sir George Prescott) was proposed by **General Webber**, seconded by **Mr. Joshua King**, and carried unanimously.

The Auditors (Messrs. Cooper Bros.) having been re-elected,

The following resolution was proposed by the **Chairman**, seconded by **Mr. Garcke**, and carried unanimously—viz., "That of the unissued capital of the Company, now amounting to 11,512 shares of £5 each, 6,000 shares of £5 each, and numbered 14,001 to 20,000 inclusive, shall be, and the same hereby are, created and made preference shares, and that such shares shall confer on the holders thereof the right to be paid out of the profits of each year a preferential dividend for such year at the rate of 6 per cent. per annum and no more, and every holder of preference shares shall have one vote for every preference share held by him."

After some remarks made by shareholders, the meeting concluded with a vote of thanks to the Chairman and Directors. It was stated that if the shareholders desired it, next year's meeting would be held in the City instead of at Chelsea.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

The twenty-eighth ordinary general meeting of this Company was held on Wednesday at Winchester House, Mr. C. W. Earle presiding.

The **Chairman** stated that if the report and account were adopted the meeting would constitute somewhat of an epoch in the financial history of the Company, inasmuch as it would free them of the incubus of arrears on the preference dividend which had been in existence since 1880. It was also a marked period in this respect, that, for the first time since 1878, they were able to pay a dividend upon the ordinary shares. The gross revenue had increased by £1,210, while the expenses showed a reduction of £5,173, the latter item being attributable to the fact of their not having had so many cable repairs. The subsidy received from the colony of Martinique had been only £500, as against £1,000 in the corresponding period. It was impossible to conceal the fact that there was no growth or progress in the telegraphic returns in the West Indies, which must, to some extent, always remain restricted. They were not wholly free from competition, as there was an occasional rumour of what is called a tactical line, or, in other words, a line to serve military purposes in time of war, which was to be free from all foreign interference. There was also another class of competitor, which was known as the National Susceptibility Cable. Under that class could be put the French cable which was going into their regions. It had been constantly urged on the Company that they should duplicate the cable between the island of Barbadoes and the colony of British Guiana, and that they had now consented to do, as the colonies had granted them an extension for 10 years of their subsidy without alteration of their terms. To pay the expenses entailed by the duplication, it had been decided to raise the money on capital account, the plan being to issue debentures. The receipts showed a slight falling off, but that was comparing them with one of the most successful sugar-growing years, and in reality they were on a level with those of the year before. He concluded by moving the adoption of the report, and the payment of a dividend of 6s. per share on the first preference shares, 34s. 6d. per share on the second preference share (*i.e.*, 28s. 6d. balance of arrears and 6s. dividend), and 9d. per share on the ordinary shares, free of income tax.

Sir James Anderson seconded the motion, which was carried unanimously, as was also another sanctioning the borrowing by the Board of £100,000 by the issue of debentures.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

The twenty-first ordinary general meeting of this Company took place on Friday, 8th inst., at Winchester House, Mr. W. S. Andrews, presiding.

The **Chairman** stated that the receipts for the half-year ended December 31 last had again been satisfactory—viz., £108,817—or £22,414 in excess of those of the corresponding period of the previous year. The large increase was due to the speculation, the excitement, and the state of politics in the countries served by their lines. The half-year's expenses had been £37,200, or £3,191 less. Having given the details of the expenses and drawn attention to the increased work done, he stated that they had not had to charter any ship this time, a fact which removed a charge of £8,531 from their accounts. This sum was, however, reduced to the net figure of £5,434 by the larger expenditure in connection with the Company's own vessels, the "Norseman" and the "Viking." Including the sum brought forward (£5,751), and the dividend on the Platino shares (£9,233), they had £86,602 to deal with, and deducting the debenture charges and £20,000 added to their reserve fund, they had left £47,502, out of which they proposed a dividend of 9s. a year, making 5 per cent. for the year, which would require £41,432. He proposed the adoption of the report and the payment of the dividend recommended, which was carried unanimously.

COMPANIES' REPORTS.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.

Directors: Charles Nash, Esq., J.P. (chairman); Mark Whitwill, Esq., J.P. (deputy-chairman); Henry Fedden, Esq.; Thomas Pole, Esq.; Richard Cory, Esq., J.P., Alderman; J. Staats Forbes, Esq., and J. W. Batten, Esq. (nominated by the National Telephone Company, Limited, under agreement). General manager and secretary: Henry F. Lewis.

Report of the Directors for the year ending December 31, 1890.

The Directors herewith submit to the shareholders the statement of receipts and expenditure up to the end of last year, and also of the present position and prospects of the Company. The capital expenditure for the year ending December 31, 1890, was £24,415. 15s. 6d., making a total of £164,409. 12s. 2d. to date. The gross revenue of the Company for the year 1890 was £46,860. 15s., against £39,046. 19s. 6d. for the year ending December 31, 1889. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond December 31, 1890, is £14,212. 19s. 1d., against £12,292. 19s. brought in from the previous year. The whole of the Company's plant has been fully maintained and, where required, renewed out of revenue. The Company have continued to substitute, at considerable expense, a large amount of copper and bronze wire for iron, which has increased the efficiency and durability of the plant. The working expenses, including maintenance and all working charges for the year 1890, have been £13,775. 18s. 1d., against £11,936. 18s. 5d. for the year ending 31st December, 1889.

Balance of net revenue account	£9,177	7	3
Dividend of 6 per cent. on the paid-up preference share capital for year ending 31st December, 1890.	6,000	0	0
Balance for appropriation, as per statement at end of accounts	£3,177	7	3

The Directors recommend that the reserve fund, now standing at £1,700, be increased by the addition of £500; and that the balance, £2,677. 7s. 3d., be carried forward. The number of subscribers to the exchange system and of private line renters has considerably increased, and the progress made during the year is considered to be most encouraging. The respective totals at the close of the years 1889 and 1890 were as follows:

	Exchange.	Private.	Total.
December 31st, 1890	2,875	712	3,587
December 31st, 1889	2,392	671	3,063
Increase in 1890	483	41	524

Mileage of trunk and renters' wires:

Erected up to December 31, 1890	5,018 miles.
Erected up to December 31, 1889	4,115 ,,
Increase representing new business during 1890	903 ,,

In addition to the above, 160 miles of wire have been renewed during the year. The Company has increased its trunk system, so that on December 31, 1890, it had 470 miles of trunk pole lines connecting towns with each other, carrying 2,182 miles of wire; against 383 miles of pole lines, carrying 1,804 miles of wire, at the corresponding date in the previous year. The continued rapid growth of the use of the Company's extensive system of trunk lines will be seen from the following figures:

	Calls.
4 months ending December, 1887	27,338
12 ,, ,, 1888	142,443
12 ,, ,, 1889	184,754
12 ,, ,, 1890	249,160

Each call is answered, so that the number of communications has been double these figures. The foregoing figures form conclusive evidence of the increasing appreciation by subscribers and the public of the convenience and economy of telephonic inter-communication between towns, and represent a remarkable development of this branch of the Company's business. The Company's trunk system is now consolidated into three groups, the towns in which are in speaking communication. The first consists of Bristol, Bath, Clevedon, Weston-super-Mare, Sharpness Dock, Gloucester, Cheltenham, Worcester, Newport, Pontypool, Cardiff, Penarth, Barry Dock, Pontypridd, Aberdare, Merthyr, Tredegar, Swansea, Morriston, Neath, Briton Ferry, Port Talbot, and Llanelly. The second group connects together Bournemouth, Christchurch, Boscombe, Southbourne-on-Sea, Poole, Southampton, Winchester, Portsmouth, Gosport, Fareham. The third consists of Plymouth, Devonport, Mutley, Plympton, Ivybridge, Totnes, Buckfastleigh, Ashburton, Newton Abbot, Paignton, Torquay, Brixham, Dartmouth. Since December last Weymouth and Dorchester have been connected together, and the trunk lines between Exeter and Newton Abbot with extra wires between Newton Abbot and Torquay are in course of construction. It is the Company's intention to open exchanges at the following places as soon as they have sufficient encouragement: Bridgwater, Camborne, Chippenham, Clevedon, Dawlish, Dorchester, Exmouth, Falmouth, Great Malvern, Hayle, Hereford, Penzance, Redruth, Salisbury, Stroud, Swindon, Taunton, Tavistock, Teignmouth, Trowbridge, Truro, Wellington (Salop). It is the Company's intention, as soon as they receive sufficient support, to connect the following places by trunk lines: Bristol with Bridgwater, Taunton, and Exeter;* Plymouth with Horrabridge, Tavistock, and Truro; Truro with Falmouth and Redruth; Redruth with Camborne; Camborne with Hayle; Llanelly with Carmarthen; Carmarthen with New Milford; Bath with Chippenham and Salisbury; Salisbury with Winchester; Poole with Dorchester; Gloucester with Stroud; Cheltenham with Tewkesbury; Worcester with Great Malvern; Hereford with Shrewsbury; Shrewsbury with Wellington and Oswestry; Ryde with Newport, Ventnor, and Sandown (Isle of Wight). The Company has continued to keep in view the importance of connecting the principal towns of their district with the metropolis, and arrangements with the National Telephone Company for the construction of a line putting Bristol and the South-Western District and South Wales in direct communication with London have been frequently considered. It is also intended to connect Bournemouth, Southampton, and Portsmouth with London, *viâ* Winchester, Basingstoke, and Reading, when the necessary arrangements are completed. Many enquiries having been received urging the importance of a connection with Birmingham, Manchester, and Liverpool, trunk lines have been run between Gloucester, Worcester, and the boundary of the National and this Company's districts; thus that portion of this Company's extensive trunk line system, embracing Bristol, Bath, Gloucester, Newport, Cardiff, Swansea, etc., is now in communication with Birmingham, Liverpool, and Manchester, and the many other important towns connected therewith in the north and Midland district. Additional call-rooms for the use of subscribers and the public have been opened during the year in the various towns, where, on payment of 2d., the Company's local exchange subscribers may be spoken with; or, on payment of a small toll, according to distance, any person can speak to any town connected by trunk lines; the Company's subscribers and their representatives having the important advantage of the free use of all call-rooms in any town in the Company's district where they may happen to be, for local communication with other subscribers in that town. A further and novel extension of call-room facilities has just been made by the Company issuing a complimentary call-room pass for use by the lady members of subscribers' families available for local calls made by the bearer in any town in the Company's district where there is a call-room. The convenience of the telephone to ladies when in the neighbourhood of any of the Company's numerous call-rooms will not fail to be appreciated, while at the same time the Company will gain advantage by making their extensive system of telephone exchanges better known and increasingly popular. The Directors have pleasure in acknowledging the uniform courtesy of the permanent officials of the Post Office department. Mr. Charles Nash and Mr. Richard Cory, directors, retire by rotation, but are eligible for re-election. Messrs. Hudson Smith, Briggs, and Co., the auditors, retire, but are eligible for re-election.

WEST COAST OF AMERICA TELEGRAPH COMPANY.

The Directors state that the gross income of the Company was £65,323. 15s. 4d., against £84,457. 13s. 1d. for the previous year. The addition of £517. 10s. 3d. brought forward makes a total of £65,841. 5s. 7d., and, deducting from this the debenture interest and all other charges, as well as the interim dividend of 3s. per share paid in July last, there remains the sum of £22,195 12s. 11d. Out of this amount the Directors have transferred £16,000 to the reserve fund, bringing it up to £80,000, written off £1,000 from the value of the repairing steamer "Retriever," and now recommend the distribution to the shareholders of a final dividend for the year 1890 of 2s. per share, payable on 20th inst., leaving £2,195. 12s. 11d. to be carried forward. During the Chilian revolution, which broke out in January last, and unfortunately still continues, the cables of the Company have been cut by both Government and Opposition forces; the Company has, however, received partial compensation for the interference of traffic.

NEW COMPANIES REGISTERED.

Art Workshops, Limited.—Registered by Adams and Adams, 8, New-court, Lincoln's-inn, W.C., with a capital of £30,000, in 1,100 guaranteed ordinary shares of £10 each and 19,000 ordinary shares of £1 each. Object: to acquire the business carried on at 58A, Brompton-road, 31, St. George's-place, and 5, Wilton-crescent-mews, Brompton, in accordance with an agreement, made April 30, between William B. Creigh of the one part and William Henry Samuel Thompson, on behalf of the Company, of the other part, and to carry on the business of buying and selling antique silver plate, building and decorating, cabinetmaking, buying and selling shops, land, etc., and electrical engineering. The first subscribers are:

	Shares.
W. B. Creigh, 31, St. George's-place, S.W.	1
W. H. S. Thompson, Oakland-grove, Uxbridge-road	1
J. Frazier, 3, Guthrie-street, Chelsea	1
L. F. Silas, 11, Waterton-road, Fulham, S.W.	1
T. Witty, 67, Marlborough-road, Chelsea	1
R. M. Lambert, 21, Sussex-street, Pimlico	1
J. W. Blake, 25, New-street, Chelsea	1

The regulations contained in Table A mainly apply.

Boy Messengers and Electric Call Company, Limited.—Registered by P. B. Ryan, 11, The Members'-mansions, Victoria-street, with a capital of £200,000 in £1 shares. Object: to acquire the business of the Boy Messengers, Limited, and to work the messenger and electric call system in London and elsewhere, within a radius of five miles from the General Post Office. The first subscribers are:

	Shares.
P. B. Ryan, 11, The Members'-mansions, Victoria-street	1
R. Leonard, 58, Elsham-road, Kensington	1
R. King, 3, Old Serjeant's-inn	1
L. D. Tottenham, Aylesbury House, St. Leonards-on-Sea	1
C. R. Langtham, 1, Fairmead-road, Holloway	1
J. L. Burn, 46, Church-street, Rotherhithe	1
T. Guyatt, 3, Lorne-road, Stroud Green, N.	1

There shall not be less than three nor more than 12 Directors. The first are Captain W. H. Davies, Lord Frederick Hamilton, Sir Frederick Milner, Bart., M.P., the Hon. P. B. Lyon, and R. King. Qualification, £100. Remuneration, £2,500, divisible.

City of Bath Electric Lighting and Engineering Company, Limited.—Registered by Kingsford, Dorman, and Co., 23, Essex-street, Strand, W.C., with a capital of £60,000, in 5,500 ordinary £10 shares, and 50 £100 founders' shares. Object: to adopt and carry into effect an agreement made May 2 between Henry George Massingham of the one part and the City of Bath Electric Lighting and Engineering Company, Limited, of the other part, and to carry on generally the business of an electric light and power company. The first subscribers are:

	Shares.
T. Vaughton, 7, Cavendish-place, Bath	50
J. G. Jervois, 16, Lansdown-place East, Bath	50
A. Pitman, 12, Royal-crescent, Bath	50
E. B. Titley, 15, Orange-grove, Bath	50
H. N. Garrett, 101, Sydney-place, Bath	50
E. Pitman, 12, Royal-crescent, Bath	50
W. Jeffery, 2, Northumberland-buildings, Bath	10

There shall not be less than five Directors. The first are Lieut.-Colonel Theo. Vaughton, H. N. Garrett, A. Pitman, Major-General J. G. Jervois, and H. G. Massingham—all of Bath. Qualification, 50 ordinary or five founders' shares. After payment of a 6 per cent. dividend upon the ordinary and founders' shares, the remuneration of the Directors shall be £500, divisible; failing the payment of such dividend, the sum of £250, divisible. Such sum of £500 shall be increased as soon as the actual paid-up capital, exclusive of founders' shares, exceeds £50,000, by a further sum of £50 for every £10,000 of additional share capital actually paid up.

Fowler Insulator Syndicate, Limited.—Registered by Richard Hewlett, 31, Essex-street, Strand, W.C., with a capital of £6,000 in £1 shares.

European Sims-Edison Electrical Torpedo Company, Limited. Registered by J. Andrew, 15, Marriott-road, N., with a capital of £201,000 in 10,000 ordinary £20 shares, and 1,000 £1 founders' shares. Object: to acquire certain patents relating to torpedoes, and to carry on the business of an electrical company in all its branches in Great Britain and any part of the world. The first subscribers are:

	Shares.
E. H. Edwards, 30, Pellerin-road, Stoke Newington, N.	1
E. Sorrell, Oak Cottage, Fowler-road, Forest Gate, E.	1
J. Andrew, 15, Marriott-road, Tollington-park, N.	1
A. M. G. Carter, 40, Denning-road, Hampstead, N.W.	1
R. H. Ibotson, 37, Chatham-road, Wandsworth Common, S.W.	1
W. Brown, 121, Hungerford-road, N.	1
S. Woodham, 82, Evelina-road, S.E.	1

There shall not be less than three nor more than 12 Directors; the first are the signatories to the memorandum of association.

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* The completion of the above, and also of the section from Exeter to Newton Abbot, will bring Plymouth, Devonport, Mutley, Paignton, Torquay, Brixham, Dartmouth, and Totnes into connection with Bristol and the many other towns connected with that city. The section from Bristol to Weston-super-Mare is complete and at work.

Qualification, being a shareholder. Remuneration to be determined in general meeting.

Roper's Electrical Engineering Company, Limited.—Registered by J. M. Urquhart, 10, Denbigh-street, Warwick-square, S.W., with a capital of £15,000 in £1 shares. Object: to acquire the business of Roper's Electrical Engineering Company (late John and William Roper), electrical engineers, Trafalgar Works, Trafalgar-street, Bradford, Yorkshire, and to carry on and extend the same. Registered without articles of association.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the past week were £4,981.

City and South London Railway.—The receipts for the week ending May 9th were £695, against £733 for the previous week, and £784 for the week ending April 25th.

Western and Brazilian Telegraph Company.—The receipts for the week ended May 8, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,964.

St. James's and Pall Mall Company.—Application has been made to the Stock Exchange Committee to appoint a special settling-day in and to grant a quotation to the ordinary and preference shares of the Company.

PROVISIONAL PATENTS, 1891.

MAY 4.

7667. **Improvements in dynamo-electric machines and electric motors.** Hugh Longbourne Callendar, 2, Princes-mansions, Victoria-street, London.

7688. **A spiral filament for incandescent electric lamps.** Arthur Saunders, 4, Inverness-terrace, Hurlingham-road, London.

7697. **Improvements in electrical accumulators or storage batteries.** Chaimsonovitz Prosper Elieson, 4, South-street, Finsbury, London.

7699. **Improvements in machines for making storage battery plates.** Herbert John Allinson, 53, Chancery-lane, London. (Patrick Kennedy and Charles James Diss, United States.)

7700. **Improvements in storage battery plates.** Herbert John Allison, 52, Chancery-lane, London. (Patrick Kennedy and Charles James Diss, United States.)

7701. **An improved storage battery plate and method of making same.** Herbert John Allison, 52 Chancery-lane, London. (Patrick Kennedy and Charles James Diss, United States.)

7702. **Improvements in or relating to the construction of electric lampholders, and other electric appliances.** Albert Hoster, 51, Cannon-street, London.

MAY 5.

7715. **Improvements in storage batteries.** George Arthur Washburn, 52, Chancery-lane, London. (Complete specification.)

7728. **Improvements in lampposts or columns for electric arc lighting.** John Lea, 5, Aberdeen-terrace, St. James's End, Northampton.

7755. **Improvements in and relating to electric motors or dynamo-electric machines.** Henry Harris Lake, 45, Southampton-buildings, London. (The Crocker-Wheeler Electric Motor Company, United States.) (Complete specification.)

7762. **Improvements in reciprocating electric engines.** Charles Joseph van Depoele, 45, Southampton-buildings, London. (Complete specification.)

7778. **Improvements in or connected with electric conductors.** William Phillips Thompson, 6, Lord-street, Liverpool. (James B. Williams, United States.) (Complete specification.)

7781. **A method or means for converting an electric current of constant periodic electromotive force into a current of constant intensity, and a current of constant intensity into one of constant difference of potential.** Paul Boucherot, 18, Buckingham-street, Strand, London.

7782. **Improvements in electrical induction apparatus.** Charlton James Wollaston and Francis John Mudford, 47, Lincoln's-inn-fields, London.

MAY 6.

7822. **Thermo-electric stove for heating purposes, and also for producing electricity.** Paul Giraud, 52, Chancery-lane, London.

7824. **Improvements in or relating to galvanising metals.** Walter Skaife, 46, Lincoln's-inn-fields, London.

7831. **Improvements relating to the manufacture of insulating partitions for use in primary and secondary batteries.** Hélène Reynier, 45, Southampton-buildings, London.

7850. **Improvements in automatic telephone exchanges.** William Wilson Horn, 151, Strand, London. (Almon B. Strowger, United States.

MAY 7.

7857. **Improvements in the construction of rheostats or similar electrical instruments.** Frank Bryan and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

7858. **Improvements in switches used for electrical purposes.** C. Scott Snell and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

7863. **An improved method of and means for cultivating land by the employment of an electric current.** Richard Richardson Hutchinson, William Benjamin Hutchinson, and Jesse Hutchinson, 11, Furnival-street, London.

7878. **Improvements in appliances for preventing ignition of gases in connection with dynamos, motors, or other electrical apparatus.** Frederick John Rowan and William McWhirter, 88, St. Vincent-street, Glasgow.

7911. **An electric switch.** George Sylvester Grimston, 28, Southampton-buildings, London.

7912. **An electric capstan.** George Sylvester Grimston, 28, Southampton-buildings, London.

MAY 8.

7937. **Improvements in or relating to electric resistance devices for measuring electric currents.** Charles Walter Cox, 6, Lord-street, Liverpool.

7949. **Improvements in secondary batteries.** Pearson Goward, 6, Bream's-buildings, London.

7954. **Improvements in and relating to electric call apparatus.** Graydon Poore, 70, Chancery-lane, London.

7960. **Improvements in apparatus for use in the manufacture of metal tubes, cylinders, or other articles by electrodeposition.** Richard David Sanders, 4, South-street, Finsbury, London.

7970. **Improvements in distributing electric energy.** Emil Alfred Wahlström, 37, Chancery-lane, London.

MAY 9.

7976. **Improvements in handles for electric light switches.** Gustav Binswanger, 71, Queen Victoria-street, London.

7979. **Improvements in electric accumulators or secondary batteries.** George Edward Barker Pritchett, Oak Hall, Bishop's Stortford.

8008. **Improvements in or connected with electric bells for use as burglar or fire alarms, or the like.** Joseph William Henry Coles and Percy Ablitt, Garrett, 47, Lincoln's-inn-fields, London.

8009. **Improvements in and relating to electric call apparatus.** Graydon Poore, 70, Chancery-lane, London.

8031. **Improvements in apparatus for heating and welding by the electric arc.** Henry Howard, 24, Southampton-buildings, London.

8034. **An improved device for facilitating the connection and disconnection of electrical conductors.** Alfred Lyster Shepard, 45, Southampton-buildings, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1890.

6083. **Electric propulsion of tramcars.** Gordon. 1s. 1d.

6726. **Electrical timepiece, etc.** Von Hefner-Alteneck. 8d.

7981. **Dynamos, etc.** Sechehaye. 11d.

9361. **Electric reduction of metals.** Willson. 11d.

15274. **Electric lighting, etc.** Bright and Engelbach. 8d.

18180. **Primary batteries.** Forbes. 11d.

1891.

2862. **Electric fire engines.** Dewey. 8d.

3349. **Electric welding apparatus.** Dewey. 8d.

3650. **Electric motors for clocks, etc.** Pope. 8d.

3765. **Electric arc lamps.** Buchanan. 8d.

4499. **Microphones.** Oppenheimer. (Actien Gesellschaft Mix and Genest.) 8d.

4751. **Electrical transportation systems.** Imray. (Wheeler and another.). 8d.

4758. **Electric railways.** Clark. (The Waddell-Entz Electric Company.) 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9⅛
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Madrid.—It is calculated that at Madrid as many as 28,000 lamps are now supplied from the central stations.

Godalming.—The Godalming Electric Lighting Committee are going to expend five guineas on advice as to the adoption of electric light in their town.

Llanelly.—The Bill to confirm the provisional order for electric lighting of Llanelly has passed through the committee stage at the House of Commons.

Royal Institution.—To-night (Friday) at nine o'clock, Prof. J. A. Ewing, M.A., F.R.S., will give a paper before the Royal Institution on "The Molecular Process in Magnetic Induction."

Another World's Fair.—It is announced that a world's fair, to celebrate the four hundredth anniversary of the discovery of America by Columbus will be held in Rio Janeiro, under the auspices of the Brazilian Government, in November, 1892.

Bath.—The report of the Electric Light Committee upon Prof. Forbes's statement upon the town lighting came before the Bath Town Council again last week, and after much discussion and cross-voting, was finally referred back to the committee.

The Telephone in Arran.—The Duke of Hamilton is having his shooting lodge at Dougarie, his residence at Brodick Castle, and Strabane House, the residence of his chamberlain, connected by telephone with the post office at Brodick. The wires are 14 miles in length.

Aberdeen Railway Station.—The Great North of Scotland Railway Company are remodelling the Palace Hotel, Aberdeen. The whole building is to be lighted by electricity and ventilated by mechanical processes. Messrs. Matthews and Mackenzie are the architects.

Paris Company.—A company has been organised in Paris to carry out the concession for the sector granted to M. Mildé. The directors include M. Mounier, the Comte de Champflour, and Messrs. Boddington and King. The consulting engineers are Messrs. Hospitalier, Hopkinson, and Preece.

Electric Railway.—It is reported that a company has been organised to construct an electric railway from Rochester, N.Y., to Niagara Falls, a distance of 80 miles. The surveyed route passes through 20 villages which may be expected to materially benefit by the additional means of transport.

Crompton Travelling Crane.—A curious error is to be noticed in the recent French description of this electric travelling crane in the *Revue Industrielle*, where it is termed a "Grue Roulante à Vapeur"—*i.e.*, "steam" travelling crane. The very full description of the illustrations, however, combat this misnomer.

Book Received.—We are in receipt of a copy of the ninth edition, revised and enlarged, of the well-known work on "Telegraphy," by Messrs. Preece and Sivewright, published by Longmans (price 6s.). There are now 265 cuts as compared with 194 in the last edition, and chapters on multiplex telegraphy and on instruments for testing have been added.

Progress at St. Pancras.—The Electricity Committee reported to the St. Pancras Vestry last week that satisfactory progress was being made with the works on the Stanhope-street site, and that preparations were being made to put in the engines and dynamos. Also that the laying of the mains in the Tottenham Court-road was progressing satisfactorily.

Provisional Orders.—A number of Bills giving powers for laying electric lighting mains in Bolton, Coventry, Dewsbury, Hanley, Harrogate, Kidderminster, Southport, and Stockport passed through committee in the House of Commons on Thursday, May 14. Among the conditions of the Bills is one that the electric current should be supplied by meter to consumers.

Central Station Management.—Mr. Horatio A. Foster is giving a series of articles in the New York *Electrical Engineer* on "Central Station Management and Finance." These, of course, apply to American practice, but some of our electrical engineers may like to know where they can see these details of organisation of electric supply companies, daily report forms, and other such matters.

Telephone in Barrow.—The important shipping town of Barrow-in-Furness has been connected by the National Telephone Company with its interurban system, and can now speak with Liverpool, Manchester, Wigan, Bolton, Blackburn, Blackpool, Preston, Lancaster, Burnley, Accrington, Todmorden, Bradford, Leeds, Huddersfield, Dewsbury, York, Lincoln, Nottingham, Birmingham, London.

South London Railway.—The "twopence any distance" arrangement on the electric railway was widely thought too simple a system to continue, and workmen have been found to grumble very much at paying full fares for half distances. The tariff has tentatively been lowered to 1d. at The Elephant and Castle—the exact halfway station of the line—but only after the first morning rush to the City.

Electric Osmosis.—In a letter to the *Journal* of the Society of Arts for May 15, Mr. J. S. Pennington (retired Madras Civil Service) writes to claim the invention of "electric osmosis," or the transfer of drugs into the human body by electric current for Prof. D'Odiardi, of Belgium, who described the process in a sealed letter sent to the President of the Faculty of Medicine at Brussels before the opening of the exhibition of 1889.

Brussels.—Electric companies are again invited to submit schemes for electric lighting of the town to the Brussels Municipality. The station must have a capacity of 20,000 lamps, and must be placed upon certain bare sites now at liberty. The station must be designed to allow for extensions. The Municipality gives no indication upon the price of sale of the current, the data in their possession having lost their value since the recent reduction in the price of gas.

St. Pancras.—Tenders are required for supplying and erecting arc lights, columns for same, and road shelters, either together or separate, for the Vestry of St. Pancras. Copies of specifications, schedules, and designs can be obtained at the office of Prof. Henry Robinson, C.E., engineer to the Vestry, 13, Victoria-street, S.W., on payment of 10s. (which will not be returned), on or after 23rd inst. Tenders to be sent in by June 1 to Mr. T. E. Gibb, vestry clerk, Vestry Hall, Pancras-road, N.W.

Weems Electric Railway.—A speed of 125 miles an hour has been reached on the experimental track of the Weems electric railway at Laurel, Baltimore. A company has now been organised in New York with a capital of 2½ million dollars, with offices at 32 and 34, Vesey-street, New York, to carry the scheme into practical operation. Factories for the manufacture of the motors and the cars to be used on the new system are to be erected, and the work, it is stated, will be pushed with all rapidity.

Cost of Accumulator Traction.—The cost electric traction by means of accumulators is al that of the horse cars on the Boston (U.S.) West End line, according to Mr. Whitney, the president. For March, notwithstanding the large cost of power, it was 2d. a mile less than horses, and the company believe when their power-house is finished, the cars will be run at a saving of 3d. a mile. It would be interesting to learn what the company allow for depreciation of cells.

Wigton.—Letters from Messrs. Nicholson and Jennings, Newcastle-on-Tyne, were read, at last week's meeting of the Wigton Urban Sanitary Authority, stating that that firm was now submitting schemes for the electric lighting of several towns in the North of England, and offering to supply Wigton. A good deal of discussion ensued, Mr. Aird saying that £165 per year was not much more than they were paying now, a remark with which Mr. Brown concurred. It was resolved that the letters lie on the table until they had a larger meeting.

Indian Lighthouses.—An important outcome of the report of Mr. Douglas to the Board of Trade on the subject of lighthouses in India and Burmah is that the Madras Presidency is to have a superintendent of lighthouses, who is to be conversant with the machinery and fittings of the lamp apparatus of lighthouses in view that when the lamp gearing gets out of order it may at once locally be attended to. Such a man, it is understood, has been secured, who will have his headquarters at Madras, and will have the supervision of 25 lighthouses in the Presidency.

Berlin Tramways.—The Great Berlin Tramway Company recently considered the advisability of substituting electric tramcars for horse cars in Berlin. The company has now despatched its chief engineer to Buda-Pesth to study the system of electric tramways in that city, which have proved to be a commercial success, this being considered the first occasion that such has been the case on the Continent. In case the system in operation in Buda-Pesth is found suitable for Berlin, the company proposes to adopt it gradually and dispense with horse cars.

Electricity Applied to Organs.—Mr. Hope Jones, of Liverpool, who has already built and used an electric organ, stated to the College of Organists, the other day, that he was confident he could construct an organ without bellows, sound boards, or even pipes, the sound being produced by electricity. Stop-knobs he has already abolished, a touch of an electric knob instantly putting the stop in or out of operation. He has also devised a "transposing switch," by which the music as it is being played can instantly be transposed to any higher or lower key by the action of electricity.

Romford.—Tenders are invited for lighting the public lamps of Romford by electricity, gas, or other illuminant, as to about 123 of such lamps from sunset to sunrise during period beginning August 10 and ending June 10, 1892 (except seven nights in each month when the lights may be extinguished at 11 p.m.), and as to about 10 of such lamps during 12 calendar months from September 1, for the Romford Local Board. Tenders, to include the cost of lighting, cleaning, and repairing, to be sent to Mr. A. H. Hunt, clerk, Romford, on June 1. Further particulars may be obtained on application to the surveyor.

Sisteron (France).—A central electric station commenced work at Sisteron on May 4th. The installation was erected for a local company, under the direction of M. Ducommun, with plant supplied by the Continental Edison Company. It contains two dynamos of 220 amperes and 110 volts, driven by a turbine of 80 h.p. The distribution is on the three-wire system, with overhead wires, furnished with lightning arresters, and cut-outs mounted in cast-iron [illegible] placed on the poles. The station can supply 700 lamps of 16 c.p., of which about 100 are to be used for the street lighting and the Mairie.

Transmission of Power to Frankfort.—The Allgemeine Company and the Oerlikon Works have definitely signed the contract for the transmission of power from Lauffen to Frankfort on the occasion of the exhibition just opened. The work will be a little more backward than was expected as the contract only stipulates the work to be finished by August 15, though then under a considerable forfeit. Herr Schneller, according to an article he has written on this undertaking, thinks there will be a loss of 100,000 watts in dry weather for the transmission of 300 h.p. 100 miles at 30,000 volts as proposed.

New Material for Accumulators.—The ordinary lead of commerce is rarely used alone for the plates of accumulator cells. Antimonious lead is employed by preference as less alterable. A new alloy of lead, very malleable, and little attacked by acids, has been proposed, says the *Bulletin Internationale*, for the manufacture of accumulators. M. Worms prepares this alloy by taking 965 parts of lead, 22 of antimony, and 13 of mercury. The lead is first melted, the antimony is then added, and the mercury is introduced at the moment of casting into ingot. A species of amalgamated lead is thus obtained which is readily laminated in thin leaves.

Leamington.—It looks as if Leamington were not going to have electric light at all—at any rate at present. The Corporation have withdrawn their application, and have insisted on certain clauses being inserted in the electric light company's proposed provisional order, which the company's agents have refused to accept. The Board of Trade have written to say that they are not prepared to grant the order without the provision—"that the local authority may at any time serve a requisition to the company requiring them to apply for an order extending the area of supply"—and that therefore they do not intend to proceed with it further.

Conversazione at Finsbury.—A very interesting collection of mechanical and art work, principally made by the students of the Finsbury Technical College, Leonard-street, was shown at a *conversazione* held in the college buildings on Friday. All the workshops were thrown open to the inspection of the guests, and numerous exhibits were shown relating to electricity, chemistry, photography, and mechanics. During the evening concerts were given by the musical committee of the Old Students' Association. Prof. Thompson lectured on "Electricity in Motion," and *tableaux vivants* formed part of the evening's entertainment, which concluded with a dance in the Cowper-street Hall.

Portadown.—The Town Commissioners of Portadown are negotiating with Messrs. J. E. Gordon and Co., of London, respecting the lighting of the town by electricity. The latter propose to supply 18 arc lamps of 1,200 c.p. and 50 incandescent lamps of 16 c.p. each, or a total of about 22,400 c.p., in place of the present lighting by gas, which, they understand, is about equal to 3,000 c.p. They are prepared to erect, maintain, and keep burning these lamps during the present lighting season for the sum of £260 per annum, provided that they obtain "sufficient encouragement from private consumers to make the enterprise remunerative." The lighting of the town by gas last year cost £229, including new lamps and wages.

Barnsley.—The Park and Lighting Committee of the Barnsley Town Council on Saturday passed the following resolution respecting the adoption of the electric light for the borough, which has been before the Council for a long time: "The committee recommend that in consequence of the withdrawal by the Westinghouse Electric Company of their tender, and of the withdrawal by the Board of Trade of their consent to overhead wires, and of the large increase thereby occasioned in the cost of supplying electricity to the borough, the consideration of the present scheme be adjourned, and that the borough surveyor be directed to prepare a scheme and plan for the supply of electricity to a similar area, and to submit the same to the consideration of the committee as early as practicable."

Squeezing the Gas Company.—At the Egremont Local Board, Messrs. Nicholson and Jennings's proposal to submit a scheme for electric lighting came at a favourable moment. The councillors thought the proposal worth considering. Gas was 4s. per 1,000, and if the Board could effect any saving by introducing the electric light they should by all means go in for it. It was proposed that the clerk write to Messrs. Nicholson and Jennings and ask for an estimate of the cost. The chairman said it would do no harm, and the proposition was agreed to. The following "aside" then occurred. The Chairman: We are awkwardly situated, you see; the great length of gas mains ——. Mr. Stout (*sotto voce*): They'll perhaps give us a reduction of 2d. per 1,000 through it. (Laughter.)

Western Counties Telephone Company.—It will be seen from a report of the meeting of this company, held in Bristol last week, and published in another column, that the directors intend, on the expiry of the last of their master patents in July next, to give the subscribers the benefit of the royalties which the company will thereafter be released from paying. The reduction in rates from this cause will take effect from August 1st. It will also be noticed that the directors desired to pay ½ per cent. to the ordinary shareholders, but were balked by the action of the London section of the board. We wonder why? For the rest, the shareholders seem to have received the chairman's statements with the favour they deserved, and we are glad to notice that this gentleman did not fail to accord honour where honour was due.

Steam and Electrical Discharge.—Before the Royal Meteorological Society, on Wednesday, Mr. Shelford Bidwell, M.A., F.R.S., exhibited an experiment showing the effect of an electrical discharge upon the condensation of steam. The shadow of a small jet of steam cast upon a white wall is, under ordinary conditions, of feeble intensity and of a neutral tint, but if the steam is electrified the density of the shadow is at once greatly increased, and it assumes a peculiar orange-brown hue. The electrical discharge appears to promote coalescence of the exceedingly minute particles of water contained in the jet, thus forming drops large enough to obstruct the more refrangible rays of light. It is suggested that this experiment may help to explain the intense darkness, often tempered by a lurid yellow glow, which is characteristic of thunder clouds.

Heckmondwike.—The Bill now before Parliament empowering the Heckmondwike Board of Health to light the town by electricity came up at the meeting last week. Mr. Redfearn urged that the Electric Lighting Committee of the Board should push forward the needful arrangements for the lighting of the town next winter. Mr. Wood suggested that the committee should at once consider the advisability of the Board doing the work, or allowing a private company to undertake it. He hoped no private company would be allowed to step in and get a monopoly, as the gas company had done, but that if there were any benefits to be derived by the adoption of the electric light in Heckmondwike the ratepayers would possess them. Mr. Redfearn stated that if the work were given to a private company it would be under an agreement empowering the Board to purchase the works at a valuati [illegible] when it thought fit.

S.S. "Norway."—The steamship companies are laying themselves out for adequate supply of vessels visiting Norway during the tourist season. The latest is s.s. "Norway," built by the Grangemouth Dockyard Company for the Steamship Faerder Company of Christiania. The vessel has a gross tonnage of 1,000 tons, being provided with triple expansion engines of 1,000 i.h.p., constructed by Messrs. Dunsmuir and Jackson, Govan Engine Works. It has been fitted up with the latest improvements in navigation appliances, including Messrs. Alley and M'Lellan's "sentinel" steam steering gear, and Messrs. Emerson and Walker's patent windlass. The electric installation throughout the ship has been supplied by the Woodside Electric Company, Glasgow. Internally it is handsomely decorated, and accommodation for 60 first-class and a large number of second-class passengers is provided.

Girone (Spain).—The town of Girone has recently been lighted by electric light. The town authorities have arranged with Messrs. Planas and Flaquer, the installation being connected with their electric machinery works already existing in the town. The Municipality will pay for 25 years an annual charge of 16,000 francs, and after this period the installation becomes the property of the town. The motive force is obtained by a turbine of 100 h.p. to 112 h.p. To supplement this a Westinghouse engine of 125 h.p., supplied from Babcock and Wilcox boilers, is installed. The distribution is carried out by two circuits one at continuous current for the surrounding district, and the other supplies three transformers, each capable of supplying 100 16-c.p. lamp and six arc lamps. The continuous-current circuit supplies four arc lamps of 1,200 c.p., 250 incandescent lamps of 20 c.p., and 430 of 16 c.p., of which 130 are for the theatre. All the conductors are overhead.

Electrical Progress in Japan.—The Japanese are exceedingly industrious in taking up recent Western inventions, and more enterprising often than some of our own colonies. It appears that the Tokyo Electrical Society has appointed a committee of 15 to make investigations and publish some rules and regulations as standard requirements for electrical installations. The telephone exchange of Tokyo City, Japan, in charge of the Government, is reported as very prosperous. The present number of subscribers is 320, while the population is 1,207,022, and the total number of houses 277,049. The Yokohama exchange has 70 subscribers. Nearly all the telegraph and post offices have been combined, and are now in a prosperous condition. An electric elevator is running every day at Tokyo in a tower. The current is supplied by the Tokyo Electric Light Company. The motor used is a 10 h.p. Sprague. Experimental works are carried on at two or three different places in the Japanese Empire for refining copper by electricity.

Carlisle.—Messrs. Carr and Co., biscuit makers to the Queen, have this week celebrated their jubilee and opened extensive new premises. The new factory is one of the largest in the county, and the works now cover over seven acres. A special feature in the buildings is the electric lighting, which has been carried out by Messrs. J. H. Holmes and Co., of Newcastle, and is the first introduction of the light into Carlisle. The dynamo, of the well-known "Castle" type, is situated in the engine-house, and is capable of giving a current of 220 amperes and 105 volts at a speed of 770 revolutions per minute. This is sufficient for working 350 incandescent lamps, and the number at present erected of 16-c.p. is about 250, as well as a Sunbeam lamp of 300 c.p. to light the approaches to the new works. Over three miles of [illegible] been fixed and one mile of various grooved wood [illegible] emainder of the wire being stretched upon earthenware insulators. When a small dynamo and accumulators have been fixed, a night circuit will be worked after the main portion of the factory is closed.

Electric Gas Lighter.—Mr. James M'Laren, engineer at the Edinburgh Public Library, has just introduced there his patent electromagnetic gas controller, which, he claims, will automatically turn up the gas when the electric light is turned off, or should anything go wrong, and in the event of the electric light coming on again will at once lower the gas, thus effecting a great saving of gas. The main valve of the apparatus is actuated (when the electric light comes on) by a small armature being attracted to the electromagnets. When the current goes off the armature is released, and the spring raises the main valve off its seat instantaneously, and allows the gas to flow to the different sunlights or burners. A small pass-by is arranged to pass a sufficient quantity of gas to supply the different burners or sunlights, just alight, which, in the event of any accident to the engines or electrical plant, at once gives the full benefit of the gas lights. When the current is switched off for the night the same advantage may be obtained. The flow of gas, he also claims, is regulated so as to avoid the gas burning too high. He has sent us a cut of this gas valve, which, in cases of public buildings, should be useful.

Flying Machines.—The discovery of a practical flying machine is an object that many men, including not a few scientists, have set before them. At the annual meeting of the National Academy of Sciences, Prof. S. P. Langley read a paper on the subject that attracted considerable attention. He said he had set up in the grounds of Allegheny Observatory a whirling machine of 60ft. diameter, driven by a 10-h.p. engine. From the study of this he had arrived at some peculiar conclusions. Suspending a plate by a spring and making an artificial wind of 40 miles an hour, he found it took less power to suspend the plate when in motion than when still. It took a second or two more for the plate to drop 4ft. when in motion than when dropped from the hand without motion—it sank slowly as if the air had become dense like cream. He comes to the extraordinary conclusion that in air the faster the speed the less power was required, that 1 h.p. will transmit a heavier weight at a rapid speed than a slow one. He thinks that artificial flight is attainable, even with present steam engines, and that with electric engines, and in the hands of engineers instead of charlatans, he hopes to see practical things come of it in a short time, possibly months instead of years.

Electric Mining in Canada.—We have long called the attention of electrical engineers in Great Britain to the possibilities before them in the colonies. From the following note in the Victoria *Colonist*, it would seem that in Canada, for mining at least, the advantages of electricity are beginning to be recognised practically: The first mining firm in Canada to call electricity to its aid in the practical development and working of its property, is the new Vancouver Coal Company, at Nanaimo, B.C. Mr. Samuel M. Robins has long been studying the subject, and, having made up his mind that electricity is cheaper and safer than steam, he has placed an order for the necessary plant, to cost complete between 50,000dols. and 100,000dols. with the Edison Electrical Company. The proposed electric plant will include an underground tramway, with power sufficient to maintain a uniform speed of eight or nine miles an hour, with 150 loaded cars continually moving. Six hundred incandescent lights are also to be used in the mines of the company, and the drills and cutters are to be operated from the same current. The new Vancouver Company will, in all probability, retain the honour of being the only firm in Canada mining by electricity but a very rt time, as others are even now considering the subject.

Leeds.—The House-to-House installation at Leeds is to distribute at 2,000 volts with sub-stations, at which transformers for smaller districts will be placed. All mains are to be underground. The company have agreed with the Corporation to allow discounts on the full number of lamps required, as follows: For 200 hours' consumption, during any quarter, 5 per cent.; 300 hours, 10 per cent.; 400 hours, 15 per cent.; 500 hours, 20 per cent.; 600 hours, 25 per cent.; 700 hours, 27½ per cent.; 800 hours, 30 per cent; 900 hours, 33½ per cent.; and 1,000 hours, 35 per cent. These discounts would thus work out: For 500 hours' use per quarter, under 6½d. per unit; for 1,000 hours, 5½d. per unit. A sliding scale for sharing profits, after the company have secured a given percentage as dividend, was also proposed to be adopted. The Board of Trade, however, objected; and in the end it was arranged that, in lieu of this arrangement, the Board should review the prices at the end of the fifth year, instead of waiting for seven years before doing so. The company have agreed to give up their rights and sell at the then value at the end of 31 years if required to do so, and to submit to a revision of charges every seven years. They have also agreed to sell at the end of 21 years with an amount extra for goodwill, or at a less period on payment of 5 per cent. dividend by the Corporation for the unexpired period on the capital.

Cable Manufacture.—M. E. Vlasto, the energetic director of the French Société Générales des Telephones, has been giving, before the Société des Ingenieurs Civils, a paper upon the manufacture and laying of submarine cables. In this he paid a very willing testimony to the extent in which English enterprise and English manufacture and English boats has had in the development of the world's network of cables. France possesses 64 cables, with a total length of 8,457 nautical miles, and of these the French Government has 55 cables of 4,068 miles length. Though, of all governments France has the greatest length of cables belonging to the State, she is not furnished with means for maintaining them, but is obliged to have recourse to England. This unfavourable position for France is beginning to change, and M. Vlasto enumerates various projects which are being inaugurated in that country, both for governmental and private manufacture, and he alluded to the status of the Société Générale des Telephones, which, deprived of its first intended work, has been led to seek other fields for its capital, and decided to install at Calais a large works capable of rivalling from all points of view the large English cable works. He points out that France at last possesses an industry hitherto monopolised by England, capable of fulfilling the wants not only of France, but of the neighbouring countries, and that this is due to private enterprise in the shape of the Société des Telephones. Cable contractors may now be assured, we presume, of keen competition, not only amongst themselves, but from the works at Calais.

British Association.—The British Association meets earlier than usual at Cardiff this year, August 19. The president-elect is Dr. William Huggins, F.R.S. The following are among the officers of the various sections. A Mathematical and Physical Science—President, Prof. O. J Lodge, F.R.S.; vice-presidents, R. T. Glazebrook, F.R.S., Prof. J. Viriamu Jones, M.A., B.Sc., Prof. H. Lamb, F.R.S.; secretaries, R. E. Baynes, M.A. (recorder), J. Larmor, Prof. A. Lodge, M.A., Prof. Selby, M.A. B: Chemistry and Mineralogy—President, Prof. W. Chandler Roberts-Austen, C.B., F.R.S., F.C.S. C: Geology, President—Prof. T. Rupert Jones, F.R.S., F.G.S. D: Biology—President, Francis Darwin, F.R.S. E: Geography, President, E. G. Ravenstein, F.R.G.S. F: Economic Science and Statistics—President, Rev. W. Cunningham, D.D., D.Sc. G: Mechanical Science—President, T. Forster Brown, M.I.C.E.; vice-presidents, Sir Benjamin Baker, K.C.M.G., F.R.S., J. Wolfe Barry, M.Inst.C.E., G. Chatterton, M.A., M.Inst.C.E.; secretaries, C. W. Cooke, Prof. A. C. Elliott, D.Sc., W. Bayley Marshall, M.Inst.C.E.; E. Rigg, M.A. (recorder). H: Anthropology—President, Prof. F. Max Müller, M.A. The first general meeting will be held on Wednesday, August 19, at 8 p.m., when Sir Frederick Abel, K.C.B., will resign the chair, and Dr. William Huggins, president-elect, will assume the presidency, and deliver an address. On Thursday evening, August 20, at 8 p.m., there will be a *soirée*; on Friday evening, Aug. 21, at 8.30 p.m., a discourse on "Aquatic Insects," by Prof. L. C. Miall, F.L.S., F.G.S.; on Monday evening, Aug. 24, at 8.30 p.m., a discourse by Dr. T. E. Thorpe, F.R.S., Professor of Chemistry in the Royal College of Science; on Thursday evening, August 25, at 8 p.m., a *soirée*; and on Wednesday, August 26, the concluding general meeting will be held at 2.30 p.m.

Continuous Arc Lamps.—Before the electrical section of the Franklin Institute on April 7th, Prof. C. Hanford Henderson presented a communication on "A Suggestion in Arc Lighting." Attention was drawn to the fact that progress in illumination has consisted in the substitution of continuous for reservoir systems. While the two essential factors, the source of heat and the substance to be made luminous, are combined in candles, oil, and gas, as usually consumed, they are separated in incandescent gas and electric lighting. In arc lighting the supply of energy is continuous, but the light-yielding substance, carbon, must be frequently replenished. The question as to whether arc lighting could not be made continuous had, therefore, presented itself, and experiments were made to use gas issuing from hollow wrought-iron terminals instead of the ordinary solid carbon. It was found that the gas and the arc formed two mutually repellent crescents of light, the terminals became fused, and one of the gas jets was closed up. This negative result not being thought conclusive, the suggestion was brought before the section in the hope of discussing the question as to whether the problem was sufficiently promising to merit further attention. Prof. Houston, in discussion, said that hollow carbons had been used at different times since 1852, fed by hydrocarbon oil, and by gas containing pulverised carbon and the like, but without success, owing to the fusion of the terminals. As the intensity of the light varies as the sixth power of the temperature, he considered a continuous arc impossible with our present materials. We have, of course, in England the hollow carbons of Mr. Saunderson, in which the stoppage of the hollow core is prevented by the introduction of asbestos fibre. We have heard nothing lately about these carbons, but the whole question seems one in which further experiment might yield very valuable results.

Dover.—The question of electric light came up again before the Dover Town Council at their meeting last week, when the report by Mr. Timmis was discussed. Councillor Pepper explained that when electric light had been first spoke of they were told the proper course was to obtain powers to supply it themselves. They had done so and spent £450, which they found they could not borrow, but must pay out of current rates. He thought the money had been well spent, as it had given them a vast amount of information. With regard to the question of their general policy in the future, he thought that it would not be advisable for them to enter into speculation. They appointed an expert, and Mr. Timmis had given in what he thought was a very fair report. The report said that if they erected one installation they would have to spend £16,000. They had no one prepared to deal with those figures of that kind there. Mr. Timmis had distinctly told them there that they would have no difficulty whatever in finding in London a body of gentlemen who would give them a good sum for the concession. He thought it was £2,000. But if they could get an offer, it was not the question of money so much as the conditions under which the offer was made. He thought they should follow out what had been told them by their expert, to obtain an offer to take over the concession. He moved that the town clerk be instructed to draw up an advertisement and conditions for the sale of the concession, to be submitted to the Council by the 26th May. Councillor Bradley suggested that the Corporation should reserve the right to purchase the undertaking at any time at a price to be fixed by certain conditions. Councillor Bradley remarked that Mr. Timmis had not furnished them with any instance in England, of a town like Dover, in which a complete system of installation had been carried out. Councillor Peake said that it appeared from the report that he wished to take them to Spain or France to show them one. It was decided to have the conditions printed, and the date on which the town clerk was to report was left open.

An English Manufactory in France.—The *Times* of Tuesday has the following: "The British Consul at Dieppe in his last report mentions that in the clock-making village of St. Nicholas, near Dieppe, an English firm has founded a manufactory for incandescent electric lamps. It is due to the enterprise of Mr. Albert Hoster, of London, who, some four or five years ago, established at St. Nicholas extensive works for electric apparatus of all kinds. The works cover about an acre of ground, and are carried out on absolutely English principles, which, as an experiment, seem to have prospered. It is believed that this establishment for the manufacture of incandescent lamps is the first established in France upon a commercial basis. The process in its essential points is kept secret. St. Nicholas being without gas supply, Mr. Hoster established a complete water-gas plant, which is now working admirably. The stock of lamps is the largest under one roof in the world. But what is most interesting is that Mr. Hoster has introduced a staff of English-trained working electricians, and, by placing them under a thoroughly experienced French manager as foreman in the various departments, the work seems to be carried on very satisfactorily, and the French workpeople also employed are working in perfect harmony with them. At the same works all the various appliances for electrical purposes are now being manufactured, principally for the French, Spanish, and Italian markets. Some of the articles cannot as yet be introduced into England on account of the patents. The consul understands that the foundation of this new trade has given great satisfaction in France, both to the authorities and to the trading community. Mr. Hoster is now taking steps to commence another branch of manufacture practically new to France—namely, the construction of bicycles and tricycles upon a very large scale. Apart from these branches, a great many hands are employed in the staple manufacture of clocks of all kinds, and numerous small mechanical articles are manufactured at Mr. Hoster's works for the English market, combining the elegance and lightness of French finish with the solidity of English workmanship. For the material and spiritual comfort of his English employés Mr. Hoster has arranged for proper services once a week at the works. He has also started a club for the men, classes for French lessons for the English, and English lessons for the French workpeople, reading classes, and social gatherings. Mr. Hoster has similar establishments in other parts of Europe."

ELECTRIC TRACTION.

IV.—UNDERGROUND LINES.

Human burrows beneath the level of the soil, and underground lines generally, may be grouped under one or other of the following two systems: First, small mining tramways or lines carried along headings and drifts of any kind; second, passenger lines of the standard size and design (such as the London Metropolitan and Metropolitan District Railways), which are perforce carried out below the normal ground level by reason of configuration of the district, or expense, if not impossibility, of construction on the street or road level.

In every instance, however, the use of electric traction is not only advisable because of greater economy in installation and working, but is absolutely necessary if the road is to be operated with comfort and efficiency. In mines, the alternatives are horse or pony traction; extremely small steam locomotives; and endless wire cables or ropes.

The first-named method is expensive to start and maintain, although, perhaps, it has hitherto proved the most flexible and easy of application. Horses, however, are subject to more heavy deterioration than machinery; besides which they must always be fed and cared for whether doing work or not.

Steam locomotives of such a diminutive size as would suffice for drawing trucks along a pit or mine level, would be perhaps the most wasteful type of motor that could be conceived, if even the risk of explosions from the engine, fire, and sparks, or the poisonous gases given off in the air through combustion of coal in the boiler, did not practically forbid their use from reasons quite sufficient for the purpose in themselves.

Wire rope transmission again may, and usually does, mean a loss of 75 per cent. of the initial energy between prime mover and the vehicles to be moved; whilst its want of flexibility and great initial cost, the lack of power to control the speed of waggon trains, and even to reverse the direction of travel, all help to show that something much better is required in order to satisfy continually improving standards.

This "something better" is provided by electricity, which stands without equal for mine and pit use.

In few fields, indeed, has electricity made more rapid strides than in that of mining. For long transmission of power, economy, and reliability, it is far superior to any other method now in the market. In many rich mining localities fuel is scarce and transportation expensive. When, however, water power is to be obtained in the vicinity, electric energy may be very easily made use of and conveyed for many miles with great saving, where present means are entirely impracticable. Moreover, the wires conveying this electric energy may be carried right into the mines and there used for all purposes where power is required—not only to work drill pumps and fans, but also for operating the waggon ways throughout.

Aside from the ability to utilise far-off water powers that might otherwise be wasted, or to economically transmit steam power from locations where there is cheap fuel, there are many advantages in the use of electrically-transmitted power in mining districts. It is readily applied to the work in question; it is easily handled, and requires but little attention.

Electric motors are used in an increasing number of mines, and those who work them are unstinted in their praise.

"The arrangement and management of power is a serious consideration also in collieries. The work to be performed is of a varied character; much of it has to be done underground under changing conditions; and where rope driving or shafting is used, constant watchfulness is necessary to safeguard against breakdowns through strains, undue wear and tear, accidents to guides, pulleys, or other gear.

"In the transmission of power by electricity, the medium is inert—in other words, the conducting wires are stationary, so that these difficulties are avoided. . . . By means of electric tram lines in the headings or levels, and by the use of telpher or aerial lines outside where the loads may be made smaller, the whole of the necessary transport service of a mine or pit can be most economically conducted.

"The advantages of centralising the power plant, and thus dispensing with comparatively inefficient fixed and locomotive engines or power furnishers, will be sufficiently obvious."

For the average type of heading, where no possible danger exists of explosions occurring by reason of any chance spark between the metallic wire or conductor running along the level and the sliding contact on the waggons, no better scheme of electric traction can be devised than the overhead system.

The conducting wires are fixed upon suitable insulators placed either at the top or sides of the heading, and by working at a proper potential the current of electric energy may be made to traverse considerable distances without undue waste.

Since, however, it is not advisable to use anything in mines or pits which cannot bear the roughest possible usage, small mining locomotives are designed and built for employment in pit levels where severe handling is to be expected, and where also there may be a danger of explosion if a single spark is allowed in the atmosphere of the mine at certain parts.

These locomotives are each provided with a set of storage cells or accumulators, which serve to increase the tractive power to some extent by reason of their added weight upon the driving wheels, and which, together with the electric motor, can all be boxed up securely so as to be practically gas and air-tight.

The storage batteries are recharged from time to time by means of a special dynamo generator at the top or bottom of the shaft, or perhaps from the ordinary electric light circuit if the mine or pit be so fortunate as to possess an installation of the kind. Of course in such a case bare metallic conductors along the galleries are not required; each locomotive is quite independent of the rest, and a breakdown which affects one has no influence upon the others.

With regard to standard size railways for passengers or goods which run more or less underground, and of which a notable instance is given by the well-known Inner Circle Railway of the Metropolis, it may be said that the imperative necessity of dispensing at almost any cost with steam power thereon, is becoming more and more apparent every day.

"Ever since the possibility of an economical system of electrical transmission of power became apparent to engineers, the application of electrical traction to railways has been regarded as only a question of time.

"Underground railways in particular have always seemed to suffer for want of some economical method of working by which steam locomotives would be dispensed with."

The objections to air-defiling steam power are quite obviated by the use of electricity for the purpose of propelling the trains on underground lines; whilst its much superior efficiency and economy enable electric traction to prove more satisfactory than wire rope transmission or any similar method.

Trains of the heavy type that usually run on standard passenger lines cannot, of course, be worked profitably by any modification of the storage battery or accumulator locomotive system. Such a method would demand far too enormous a weight of battery on the locomotive for any practical success to be achieved.

The conductor system is, of course, the only practicable means that should be adopted: the conductors may be fixed either on the ground-level, where they are generally easy of access, but also rather difficult to properly insulate from the ground and from one another; or they may be erected at a moderate height along the line—preferably, from posts erected in the 6ft. way—where contact carriages or brushes, fixed on the sides of the train cars, will be able to bear upon them; or, finally—and perhaps best of all—they may be suspended from or fastened to the tunnel roof, oil insulators of the usual type being largely employed to prevent any possible leakage of current.

(To be continued.)

HUTIN AND LEBLANC ROTARY-CURRENT MOTOR.

One of the most curious things about electrical inventions is the extraordinary way in which discoveries are perfected and brought out simultaneously, so to speak, in several countries. We have already alluded to and described some of these, notably the Dobrowolsky motor, and intimated that the merits of this invention are claimed to be rivalled by other motors by Haselwander and Wenström. And now we have particulars from France of a similar alternate-current motor invented by MM. Maurice Hutin and Maurice Leblanc, of which the description has recently been communicated to the Academie des Sciences by M. Cornu. This motor is claimed to present the same advantages as continuous-current motors, while at the same time allowing the transmission of power over long distances economically. The problem of the utilisation of energy by the transmission of power by alternate currents is once again, therefore, claimed to be solved, and this time in France, for the experiments undertaken with the Hutin-Leblanc motors at the works of the Société l'Eclairage Electrique in Paris show, it is stated, an efficiency of 78 per cent., with an 11-h.p. motor working at half load.

The idea of the rotary field induced in a stationary iron core is claimed—in the abstract of M. Cornu's paper in the *Bulletin International de l'Electricité*, from which we quote the following particulars—as belonging to MM. Lontin and de Fonvielle, who applied it in March, 1887, and later Prof. Galileo Ferraris utilised it in the construction of the motor which bears his name. But in this the difference in phase between two inducing currents is obtained by making them traverse, one a circuit presenting a low resistance and a high self-induction, and the other a high resistance and low self-induction. The total resistance thus becomes considerable, and results in much pure waste of energy.

Tesla avoided this capital defect by producing separate inducing currents by means of two armatures mounted on the same axle, and one lagging behind the other. The result is superior, but the dynamos are obliged to generate a considerable electrical pressure, a large part of which serves only to overcome the self-induction of the motor and not to produce power.

The question remained at this stage, when M. Dolivo Dobrowolsky—for whom the terms rotary-phase current and rotary field were created—designed a complete system, borrowing from Tesla the generating dynamo with lagging armatures, with the three wires necessary to conduct the current, and from Ferraris the motor armature short-circuited upon itself.

Abandoning the path hitherto taken, MM. Maurice Hutin and Maurice Leblanc have sought, first of all, to combat the self-induction to which every system using the alternate current gives rise. They have shown that a condenser of sufficient capacity, inserted in a circuit traversed by an alternating current, develops an E.M.F. equal and of sign opposite to the E.M.F. of induction; under these conditions the current flows as a continuous current, following Ohm's law. Further, they have deduced from researches of a purely theoretical nature that by suitably arranging the capacity of a condenser inserted in the circuit traversed by an alternating current, any required difference of phase, positive or negative, may be set up between the variations of intensity of the current, and those of the E.M.F. acting upon the circuit. It was by applying these principles that they have been able to obtain the requisite currents for the setting up of a rotary magnetic field. The corollary of their synthetic study of the induced currents under the influence of a rotary field have resulted in the establishment of the means to regulate them in such a manner that the turning couple developed on the motor axle diminishes as the speed increases; these are the conditions of working of a continuous-current motor, conditions not realised by any of the other motors mentioned above.

The Hutin-Leblanc motor, constructed upon the principles enunciated, is designed to work with currents of high frequency. The motor is of a cylindrical form, and of very small size for its power. To the field magnets are led two circuits branched upon the terminals of lead and return, one of them containing a condenser; this comprises the fixed part of the motor. The armature, constituting the revolving part, is formed of two identical circuits, each connected to a rheostat, whose resistances switched in at the moment of starting are gradually cut out of circuit as the speed increases.

This motor has no commutator, and consequently there is no sparking. It starts on load, and turns at any desired speed.

A motor fed from a dynamo giving 75 periods instead of 120 (the number for which the motor was designed), gave at half load 11 h.p., with an efficiency of 78 per cent.

THE ELECTRIC LIGHTING OF PUBLIC BUILDINGS: WITH SPECIAL REFERENCE TO THE ATHENÆUM ELECTRIC LIGHT INSTALLATION.*

BY PROF. JAMIESON, M.I.C.E., F.R.S.E.

(Concluded from page 464.)

APPENDIX.

TABLE I.—Total Number of Lamps, Current, and Power in the Athenæum.

Voltage=115 volts; 16 c.p.=·6 amperes; 150 c.p.=3 amperes; 300 c.p.=5·5 amperes.

Old building.	Number of lamps.			C.P.	Cur'nt per flat.	Watts per flat.	E.H.P. per flat.
	300c.p.	150c.p.	16 c.p.				
Basement......	—	4	66	1,656	51·6	5,934	7·95
First floor......	—	8	22	1,552	37·2	4,278	5·7
Second floor...	—	—	41	656	24·6	2,829	3·79
Third floor ...	—	—	62	992	37·2	4,278	5·73
Fourth floor...	—	—	86	1,376	51·6	5,934	7·95
Totals ...	—	12	277	6,232	202·2	23,253	31·12
New building.							
Basement......	8	—	7	2,512	48·2	5,543	7·43
Second floor..	—	—	24	384	14·4	1,656	2·2
Third floor ...	1	—	13	508	13·3	1,529·5	2·05
Fourth floor...	—	—	24	384	14·4	1,656	2·2
Totals ...	9	—	68	3,788	90·3	10,384·5	13·88
Summary of lamps in both buildings.							
Old building..	—	12	277	6,232	202·2	23,253	31·12
New building.	9	—	68	3,788	90·3	10,384·5	13·88
Grand totals ..	9	12	345	10,020	292·5	33,637·5	45·00

NOTE.—When all the above lamps were run at one time, at 115 volts potential difference at the switchboard, as measured by Sir William Thomson's multicellular voltmeter, and the amperes by Messrs. J. H. Holmes and Co.'s ammeters, the power was=44·5 e.h.p. The total lighting in candles is equivalent to 626 lamps of 16 candles each, if all the Sunbeam lamps are taken into account. This gives an average of nearly 14 lamps of 16 c.p. per e.h.p.

TABLE II.—Details of the Athenæum Dynamos Nos. 2 and 4:

Resistance of armature R_a = ·035 ω.
Resistance of magnet R_s = 26·8 ω.
Resistance of main coils R_m = ·023 ω.
Current in working circuit C_e = 140 A.
Current in F.M. coils C_s = 4·2 A.
Current in armature C_a = 144·2 A.
Potential difference at terminals E_e = 113 V.
E.M.F. generated in armature E_a = 121·3 V.
Number commutator bars = 62.
Turns of armature wire T_{aw} = 248.
Turns in shunt coils T_{sc} = 3488.
Turns in main coils T_{mc} = 90.
Armature revolutions per minute N_{ar} = 500 per minute.

Alternative-wound Dynamos Nos. 1 and 3:

Armature and series winding same as above.
Potential difference as shunt machine = 125 volts.

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* From the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland.

TABLE IV.—SOME OF THE EFFICIENCIES TO BE CONSIDERED BY THE ELECTRICAL ENGINEER, WITH SOME OF THE VALUES OBTAINED IN THE CASE OF THE ATHENÆUM INSTALLATION.

1. Electrical efficiency $= \dfrac{\text{Output in watts}}{\text{Total watts generated}} = \dfrac{C_e \times E_e}{C_a \times E_a}$ = 88·5 per cent., mean of four dynamos at $^2/_3$ load.

2. Commercial electrical efficiency $= \dfrac{\text{Output in E.H.P.}}{\text{B.H.P.}}$ = 88·5 per cent.

3. Mechanical efficiency of steam engine $= \dfrac{\text{B.H.P.}}{\text{I.H.P.}}$ = 80 per cent.

Since the dynamo armatures are coupled on axle of each engine, in taking the B.H.P. the brushes were up, and the armatures run at the normal speed of 500 revolutions per minute, hence the efficiency of 1 and 2 are the same.

4. Commercial efficiency of engine and dynamos combined $= \dfrac{\text{Output in E.H.P.}}{\text{I.H.P.}}$ = 70·8 per cent.

5. Theoretical efficiency of engine $= \dfrac{\text{Heat units per I.H.P. hour}}{\text{Total heat units in steam used per I.H.P. hour}}$ = 7 per cent.*

6. Commercial efficiency of boiler $= \dfrac{\text{Heat units in steam generated per lb. of coal}}{\text{Available heat units per lb. of coal burned}}$.

7. Theoretical efficiency of boiler $= \dfrac{\text{Heat units in steam generated per lb. of coal}}{\text{Total heat units per lb. of coal with perfect combustion}}$ = 60·6 per cent.*

8. Theoretical efficiency of whole plant $= \dfrac{\text{Heat units equivalent to } C \times E \times T}{\text{Total heat units per lb. of coal with perfect combustion in time T}}$ = 3 per cent.*

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* Since every pound of steam at 145lb. absolute has a temperature of 355deg. F., and absorbs 1,190 B.T.U. from 32deg. F., and every pound of feed-water was raised to 145deg. F. before entering the boilers, we have (145 − 32) = 113 B.T.U. imparted to every 1lb. of feed-water before it enters the boiler.

Hence (1,190 − 113) = 1,077 B.T.U. from 145deg. F. for every pound of feed-water.

The type of coal used was tested by Thomson's calorimeter, and found to be capable of only evaporating 12·5lb. of water at 212deg. F. into steam at 212deg. F. In firing the boilers under a 5½ hours' trial 6·8lb. of water were converted into steam at 145lb. pressure.

Question 1.—How much water could have been evaporated from and to 212deg. F.?

$$966 : 1{,}077 :: 6{\cdot}8 : x \;\therefore\; x = 7{\cdot}58\text{lb.}$$

Question 2.—What is the theoretical efficiency of the boiler?

$$12{\cdot}5\text{lb.} : 7{\cdot}58\text{lb.} :: 100 : y \;\therefore\; y = 60{\cdot}6 \text{ per cent.}$$

Question 3.—What is the theoretical efficiency of the whole plant?

The long calculation may be checked thus: Efficiency of boiler (60·6 per cent.) × efficiency of steam in cylinder (7 per cent.) × efficiency of engine and dynamos (70·8 per cent.) = 3 per cent.

Current in working circuit = 25 amperes.

As compound, 113 volts and 140 amperes at 500 revolutions.

Turns in shunt = 2255.

Resistance of shunt coils, 11·5 ohms.

Added when running compound, 13·5 ohms.

TABLE III.—Compound-wound Dynamos Nos. 2 and 4 at full load.

$E_e = 113$ volts.

$C_e = 140$ amperes, $\therefore C_e \times E_e = 140 \times 113 = 15{,}820$ watts.

$R_e = \dfrac{E_e}{C_e} = \dfrac{113}{140} = {\cdot}8\ \omega.$

Resistances: $R_a = {\cdot}035\ \omega$; $R_s = 26{\cdot}8\ \omega$; $R_m = {\cdot}023\ \omega$.

Currents: $C_e = C_a - C_s$; but $C_s = \dfrac{E_e}{R_s} = \dfrac{113}{26{\cdot}8} = 4{\cdot}2$ amperes.

$\therefore 140\text{ A} = (C_a - 4{\cdot}2)$, or $C_a = 140 + 4{\cdot}2 = 144{\cdot}2$ amperes.

Fall of potential:

In armature $= C_a \times R_a = 144{\cdot}2 \times {\cdot}035 = 5{\cdot}04$ volts.

In main coils $= C_m \times R_m = 144{\cdot}2 \times {\cdot}023 = 3{\cdot}31$ volts.

Total fall of potential in armature and shunt coils:

$= C_a$ or $C_m (R_a + R_m) = 144{\cdot}2\,({\cdot}035 + {\cdot}023) = 8{\cdot}36$ volts.

$\therefore E_a = 8{\cdot}36 + E_e = 8{\cdot}36 + 113 \ldots = 121{\cdot}36$ volts.

Absorption of power:

In armature $= C_a^2 . R_a = 144{\cdot}2^2 \times {\cdot}035 = 727{\cdot}7$ watts.

In shunt coils $= C_s . R_s = 4{\cdot}2^2 \times 26{\cdot}8 = 472{\cdot}7$ "

In main coils $= C_m^2 . R_m = 144{\cdot}2^2 \times {\cdot}023 = 478{\cdot}25$ "

Total loss of power.............................. = 1677·7 "

Useful power .... = 15820· "

∴ Total power generated = 17,190 "

Then, $17{,}490 : 15{,}820 :: 100 : x = 90{\cdot}4$ per cent. efficiency at full load. At $^2/_3$ load, however, dynamos 2 and 4 (with a potential difference of 116 volts and 85 amperes, or 9,860 watts) gave 91·5 per cent. The resistance of the armature and main coils were, of course, less heated by the smaller current, and hence the slightly higher efficiency.

Dynamos Nos. 1 and 3, at 116 volts and 85 amperes, give an efficiency of 85·5 per cent. They are, however, wound with much lower resistance shunt coils on their field magnets, and with their series coils cut out of circuit, so as to facilitate charging the storage cells at 135 volts when required.

TABLE V.—Cost of running the Athenæum Electric Lighting Plant.

From the Mean of 26 Working Days in February and March.

	Cost per day.		
1. Coal, 56 tons, at 13s. per ton.........	£1	7	3
2. Wages of engineers and fireman ...	0	10	1
3. Oil, waste, etc............................	0	0	9
4. Water, at £4 per month...............	0	3	0
5. Rent of engine-room	0	3	0
6. Depreciation of plant, 12½ per cent. per annum on £2,500	0	17	1
	£3	1	2

So that the £3. 5s., or 4d. per Board of Trade unit, as stated on the diagram of the load curve, appear to be more than sufficient.

WATER EVAPORATED AT 212DEG. F. AND EFFICIENCY OF ATHENÆUM BOILERS.

Steam at 145lb. absolute = 355deg. F., and absorbs 1,190 B.T.U. per pound when raised from water at 32deg. F.

But the feed-water was 145deg. F.; ∴ 145deg. − 32deg. = 113deg. F. Or, every pound of water had received 113 B.T.U. before being introduced to the boilers.

∴ 1,190 B.T.U. − 113 B.T.U. = 1,077 B.T.U. per pound from water at 145deg. F. into steam at 355deg. F.

The coal used was only capable of converting 12·5lb. water at 212deg. F. into steam of 212deg. F., thereby absorbing 966 B.T.U. I arrived at this result from tests of the samples of the coal used by Thomson's calorimeter (as described at page 38 in Jamieson's "Text-Book on Steam and Steam Engines," fifth edition).

But in the Athenæum boilers 6·8lb. of water were converted into steam at 145lb. absolute, by the combustion of each pound of coal.

Consequently, how many pounds of water would have been converted into steam from and at 212deg. F.?

$$966 \text{ B.T.U.} : 1{,}077 \text{ B.T.U.} :: 6{\cdot}8 \text{ pounds} : x \text{ pounds.}$$

$$\therefore x = 7{\cdot}58\text{lb.}$$

From the above we now can deduce the efficiency of the boiler; for,

$$12{\cdot}5\text{lb.} : 7{\cdot}58\text{lb.} :: 100 : y.$$
$$\therefore y = 60{\cdot}6 \text{ per cent.}$$

Regarding the theoretical efficiency of the whole plant, see p. 43, Table IV., No. 8 (last month's *Transactions*). We may check the result as follows:

Theoretical efficiency of boiler (60·6 per cent.) × theoretical efficiency of steam in the engines (7 per cent.) × the commercial efficiency of engines and dynamos (70·8 per cent.) = 3 per cent.

Table V.—Dimensions of the Athenæum Boilers.

Type—Dry back tubular.
Number of boilers—2.
Diameter of boilers—5ft. 9in. inside.
Length of boilers—5ft. 9in. inside.
Number of tubes in each boiler—62.
External diameter of tubes—2½in.
Furnace tubes—length, 5ft. 9in.; diameter, 2ft. 6⅞in. internal.
Fire grate—length, 4ft. 3in.; width, 2ft. 6½in. mean.
Grate area—10·8 square feet, each; 21·6 square feet, both.
Heating surface—in furnace, 30·6 square feet; in tubes, 233·3 square feet; total for both boilers, 528 square feet.
Height of chimney from firebars—110ft.
Sectional area of chimney—5 square feet.
Sectional area through tubes of both boilers—3·04 square feet.
Heating surface for each square foot of grate area—24·4.
Heating surface of feed-water heater—51·5 square feet.

Table VI.—Details of a Test of the Athenæum Boilers.

1.	Duration of each test	5½ hours.
2.	Heating surface	528 square feet.
3.	Grate area	21·6 square feet.
4.	Coal burned per hour	355lb.
5.	Coal burned per hour per square foot of grate area	16·4lb.
6.	Coal burned per hour per square foot of heating surface	·67lb.
7.	Water evaporated per hour	2425lb.
8.	Water evaporated per hour per square foot of grate area	112lb.
9.	Water evaporated per hour per square foot of heating surface	4·5lb.
10.	Water evaporated per hour per pound coal at feed temperature	6·8lb.
11.	Water evaporated per hour per pound coal at 212deg.F.	7·58lb.
12.	Temperature of feed in tank	34deg.F.
13.	Temperature of feed leaving feed heater	145deg.F.
14.	Rise in temperature due to feed heater	111deg. F.
15.	Temperature of chimney gases	550deg. F.
16.	Chimney draught	1in. water.
17.	Calorific value of the coal in B.T.U.	12,500
18.	Pounds water that would be evaporated from and at 212deg. F. with perfect combustion	12·5lb.
19.	Efficiency of boiler (theoretical) = $\frac{7{\cdot}58}{12{\cdot}5}100=$	60·6 per cent.

From another set of tests.

(1)	Coal (of above quality) per i.h.p. (net)	4·7
(2)	,, ,, e.h.p. (net)	6·7

FRANKFORT EXHIBITION.

The Electro-Technic Exhibition was opened at Frankfort-on-the-Main last Saturday, in presence of the Empress Frederick, Princess Margaret of Prussia, the Grand Duke, Princess Alix and the Landgravine of Hesse, Count Eulenburg, President of the Prussian Province of Hesse-Nassau, and the chief local dignitaries. Herr Sonnemann, chairman of the committee, after welcoming the visitors, pointed out the utility of an exhibition of that kind, and said that foreigners, as well as Germans, had recognised this by their extensive participation in it. With regard to the extent of the present exhibition, he stated that the first German show of the kind, to wit, the exhibition at Munich in 1882, had only 160 h.p. at its disposal. The Vienna one in 1883 had 1,200 h.p., while this at Frankfort, which is the first international electric exhibition, is employing no less than 4,684 h.p. He concluded by thanking the German Emperor, the Empress Frederick, the Grand Duke of Hesse, and the various German Governments for the support they had given to the enterprise. Finance Minister Dr. Miquel, as honorary president, in declaring the exhibition open, took the opportunity of thanking the Empress and the Grand Duke for the interest they had shown in the enterprise. After three cheers had been proposed by the Burgomaster of Frankfort to the Emperor, the Empress Frederick and the Grand Duke walked through the exhibition. Among other things, they heard the very successful telephonic transmission of an opera by Delibes, which was being performed in the Opera House at Munich, and then listened to an English song given by an Edison phonograph. The Empress and the other distinguished visitors expressed great satisfaction with what they had seen. In the afternoon there was a banquet, and in the evening festive performances in the Exhibition Theatre and the Opera House. The Emperor has promised to visit the exhibition on August 18.

SOME RESEARCHES IN ELECTROMAGNETIC INDUCTION.*

BY E. B. VIGNOLES.

The subject of electromagnetic induction is one whose ramifications extend into almost every commercial application of electricity. I need, therefore, little excuse for bringing before you to-night a short account of an investigation into induction phenomena which, even if it traverses somewhat well-trodden ground, presents some novel features of method and application which may perhaps repay your attention.

Before proceeding to describe to you the method used by Mr. Evershed and myself in these investigations, I may perhaps briefly state the circumstances which led to our undertaking the research. When we started our experiments some two years ago, the subject of transformers was being much discussed; and as we, in common with most other people, were rather hazy in our ideas concerning the actions of this convenient but perplexing machine, we determined to investigate these actions from the beginning by determining, *de novo*, the magnetic properties of closed rings of various materials. The method of drawing the actions of a transformer was then in process of conception, and he saw that these curves were the one thing needful. We knew, of course, that Ewing and Hopkinson had already published similar curves, but their papers are somewhat inaccessible, and their methods seemed to us open to some objections, objections of which I will treat further on.

But before I proceed to further describe the methods used, it may be as well, since the nomenclature of magnetic phenomena is in a somewhat amorphous condition, to describe the sense in which various terms will be used in this paper.

The first thing that we have strongly set our faces against is the use of the term "induction" in the sense of "induction density." It is as if we had no term for current, and used current in the sense of current density. It simplifies one's nomenclature to call B × area "the induction," just as in the case of current; and to call B the "induction density," and I shall take the liberty of doing so in this paper.

I shall not allude to "I," for the good reason that I can form no conception of what it means physically. I fancy it is something to do with the induction density that would have been present in an electric circuit if the iron which is there wasn't there! It seems useless to make such artificial distinctions, and I follow Dr. Hopkinson's distinguished example in treating of nothing but B, H, and μ.

The remaining point, as regards nomenclature, is the abuse of term "lines of force." As expressing the direction in which the induction acts at various points, they have an obvious and valuable use; but these lines do not increase or diminish as the induction becomes greater or less. Whether you have 10^{-10} or 10^{+10} units of induction, the lines of force remain precisely the same. They should be symbols of *direction* and not of *quantity*. The use of the term "lines of force" for units of induction, not only leads to false mental pictures, but it is clumsy. We were, therefore, compelled to invent a new unit for induction, as no one else had done so. This unit was born some two years ago, and was christened the "Thom," after our leading electrician. It serves its purpose; you can speak of a "thom" without committing yourself to anything, or thinking of anything in particular.

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* Paper read before the City and Guilds of London Institute Old Students' Association, May 13, 1891.

The Paris Congress has adopted a unit of induction density called the Gauss. It is really an unnecessary unit as "thoms per sq. cm." is all that is required; but it is convenient, and we have always used it. It simplifies the numbers on the curves of **B** and **H** to called 1,000 gausses, a "kilo-gauss" in the usual metric manner; and I have done this in my tables and curves, where **H** is in dynes, and **B** in "kilo-gausses."

Having thus explained my use of terms, let us return to the consideration of the action of iron in transformers.

The importance of imitating as closely as possible the action of the magnetising current in a transformer strongly impressed us. We saw that it was necessary, when investigating any induction cycle, to carry the iron through that cycle before every observation, and always to start from one extremity of the cycle.

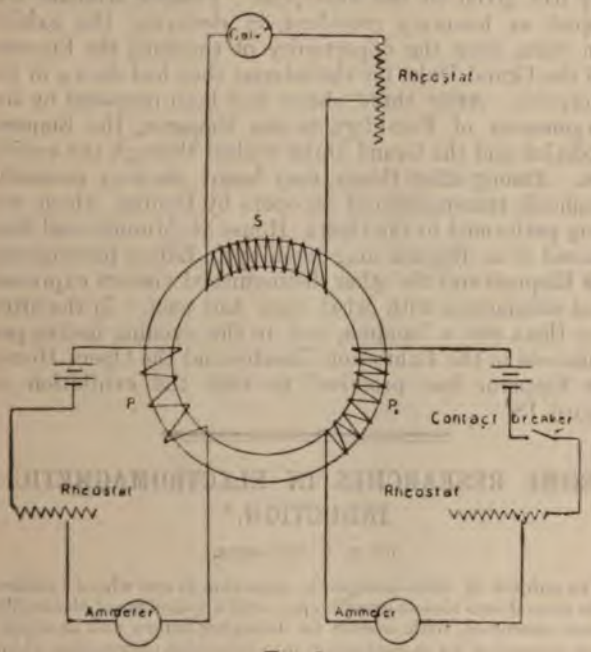


FIG. 1

It may be said that the ordinary method of procedure by reducing the current from the negative maximum by jumps to O, increasing to the positive maximum in the same way, and then reversing the process, noting at each jump the throw of the ballistic galvanometer, is equally good; but this is not so, for in a transformer you are not stopping anywhere on the force-induction curve, except at the positive and negative maxima. It might happen that the iron behaved differently in the two cases; and we know from Ewing that the induction has a tendency to creep up under the prolonged action of a magnetising force.

Magnetometer methods were out of the question, for iron rods do not behave like closed rings, unless, according to Ewing, their length is about 400 times their diameter. As we wished to experiment on masses of iron, and not on wires, which might, and in fact do, behave very differently, the minimum diameter we could have used would have been ½in. This makes our rod 18ft. long, which is somewhat alarming.

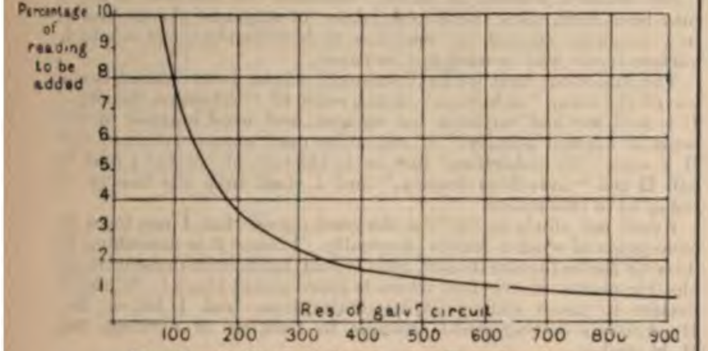


FIG. 2.—Ballisti Galvanometer Damping Curve.

Hopkinson's method is a very handy and convenient one, but the fact that it introduces other material than the one under test, and that at least two, and generally three, joints are necessary parts of the magnetic circuit, is a great disadvantage. It may be that a very small portion of the magnetising force is spent on the "return" block, but still there is always something; and that something is rendered somewhat indefinite by the hysteresis of the block. This amount may, however, be indefinitely reduced by making the block big enough, but it is not so with the joints. It will always take an appreciable percentage of the magnetising force to push the induction through these joints, and this percentage will vary in every sample of iron tested owing to minute differences in the tightness of the joint. It will be noted that since the bar has to be pulled out suddenly, the joint with the block can never be made really very tight. A modification of this method using very tight joints, and winding with two primaries (as in our method) to avoid having to pull out the test bar, might have its advantages; for it would no longer be necessary to wind each sample of iron, which is of course essential in the ring method, and it saves one joint; but turning the bars would entail nearly as much work as winding a ring, and work of a more expensive class, for any boy can wind one of our rings properly, but accurate turning would require more skilled labour. Thin laminæ of iron, as used in transformers and armatures, cannot be tested by this method, which practically puts it out of the question.

The most important experiments performed by means of rings, according to Kirchoff's method, are those of Bosanquet. He, however, did not, as far as I know, take hysteresis curves, but confined himself to average curves, obtained by means of the reversal method. For testing iron where the amount of coercive force is not required this method is excellent, and many of our curves have been thus obtained.

To obtain the hysteresis curves, and to ensure the conditions being the same as in the transformer—that is to say, that the magnetising force must always be carried from one extremity of the cycle to the point under observation at one fell swoop—we adopted the following method of winding.

The rings are generally about 13 cm. in diameter, and one or two sq. cm. in area. They are wound continuously all round with two primary coils, P_1 and P_2, and a secondary, S, is wound on generally over the primaries for convenience to produce the galvanometer deflection. One primary has preferably twice the turns of the other. In any case the currents must be so arranged that at the maximum the ampere-turns on P_2 are twice those on P_1.

The arrangement of the circuits is shown in Fig. 1, where the coils are drawn separately for the sake of clearness. They really are wound over one another.

P_1 has n turns; P_2 has $2\,n$ turns.

A current of some definite value, so arranged that the total magnetising force is of the dimensions required to keep the iron at the end of the cycle to be investigated, is kept up constantly in P_1, thus holding the iron at the negative maximum (0, Curve 1), when P_2 is not in action.

When a current of the same value, but in the opposite direction, is flowing in P_2 the iron is carried to its positive maximum, since P_2 has twice as many turns as P_1.

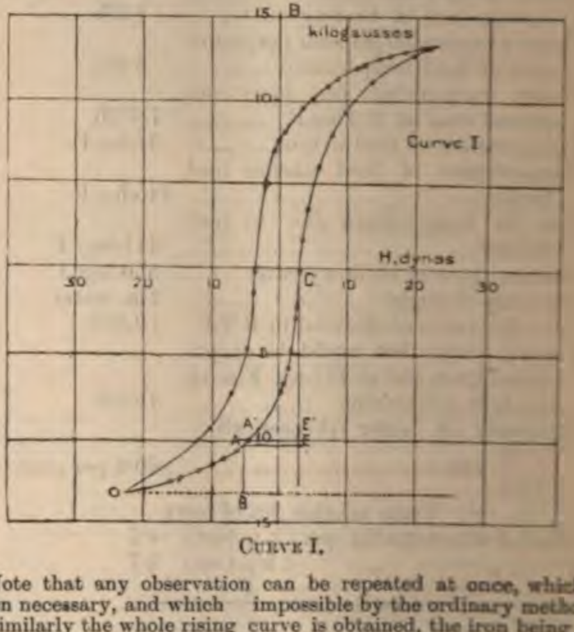
The mode of obtaining the curve is now obvious. Let curve 1 represent the cycle under investigation. The "fiducial current" in P_1 is, say, 10 amperes; this current remains on all the time the cycle is being obtained, and is kept always accurately at the same value.

Ten amperes are then put through P_2 in the reverse direction, and then broken, carrying the iron to the positive maximum, and returning to 0, the fiducial point.

The observation is then made by making a small current in P_2 (thus reducing the net ampere-turns), and noting the deflection of the ballistic galvanometer. The ordinate A B is thus obtained.

The iron must then be again carried to the positive maximum, and back to O, by making and breaking 10 amperes in P_2.

The next point is obtained similarly, by making a somewhat larger current in P_2; this gives the ordinate C D.



CURVE I.

Note that any observation can be repeated at once, which is often necessary, and which impossible by the ordinary method.

Similarly the whole rising curve is obtained, the iron being put through its cycle between each observation, to remind it that it is a transformer.

The falling curve is of course similar, and may be obtained by reversing the currents in both coils.

Now, if this curve is obtained in the ordinary manner by successive jumps, first from O to A, then from A to C, and so on, the iron has time between successive observations to creep up along the curve from A to A′ say, and the ordinate E′ C is obtained at the next jump instead of E C. The sum of the deflections is then not great enough. Also the quantities passing through the galvanometer are not as great as they are in our method, and consequently the chances of error are greater.

Curve 1 is a curve obtained by our methods, which shows its extreme value in the steep parts of the curve. Table 1 gives the actual values of the **B** and **H** (the induction density in kilo-gausses, and the magnetising force per centimetre of length in dynes), obtained by observation, and it will be noticed that even in the steepest parts the curve can be traced with absolute certainty, every observation being exactly on the curve.

TABLE I.—Wrought Iron, Unannealed.

Rising.			Falling.		
No.	H	B	No.	H	B
1	−15·75	−12·5	23	+21·5	12·9
2	−14·5	−12·35	24	18·4	12·7
3	−11·4	−11·8	25	16·95	12·6
4	− 9·3	−11·4	26	14·9	12·3
5	− 7·9	−11·0	27	13·1	12·1
6	− 5·8	−10·4	28	12·8	12·0
7	− 4·4	− 9·8	29	11·4	11·8
8	+ 0·35	− 7·2	30	8·75	11·2
9	+ 1·0	− 6·6	31	7·35	10·8
10	+ 1·4	− 5·9	32	5·2	10·0
11	+ 1·9	− 5·0	33	3·7	9·5
12	+ 2·5	− 3·4	34	0·7	7·9
13	+ 2·6	− 2·9	35	0·2	7·6
14	+ 3·3	− 0·25	36	− 0·7	7·0
15	+ 4·0	+ 1·8	37	− 3·7	− 0·25
16	+ 4·7	+ 3·4	38	− 4·0	− 1·4
17	+ 6·3	+ 5·8	39	− 5·1	− 4·8
18	+ 8·2	+ 7 9	40	− 7·2	− 7·2
19	+10·3	+ 9·1	41	−10·3	− 9·4
20	+14·0	+10·9	42	−11·5	− 9·8
21	+19·3	+12·4	—	—	—
22	+22·0	+12·9	—	—	—

It has been asserted that the induction is unstable at the steep part of the curve; this is not so, as far as masses of iron are concerned, for we have never had any difficulty in stopping at any part of the curve and reproducing an observation. In connection with this subject of instability, I may mention another point which is noticeable. Prof. Ewing found that the residual induction in his soft iron wires was very unstable; so much so, that a man walking in an adjoining passage caused enough vibration to shake all residual induction out. Mindful of this, we carefully tested our early rings for this effect; while Mr. Evershed held the galvanometer switch over, I gently stroked the ring—nothing happened; I tapped it lightly—still nothing. I ended by smiting it with a hammer, under which severe treatment it yielded up 2 per cent. of its residual induction! We concluded, therefore, that it required considerable *molar* vibration to affect masses of iron. It is not so with *molecular* vibration. A very small force applied by means of an electric current, either in the direction of the induction or at right angles to it, shakes out all residual induction.

There are two errors which must be looked for in all methods of measuring induction. First, air induction in the secondary, if it is larger in area than the iron; this becomes of importance when the permeability of iron comes down near that of air, but may be neglected in most cases for small cycles, or calculated and allowed for. Secondly, unsymmetrical winding of the primary or primaries. We found that if a primary be wound half round a ring about 4in. across, 10 per cent. of the induction leaked across through the air from end to end of the coil; thus **H** cannot be calculated, owing to the unknown distribution of the magnetising force.

The advantages of the method described being so many, we finally decided to adopt it; and proceed to manufacture our apparatus.

The ballistic galvanometer, of which details are given in Table II., appears to the naked eye a rough piece of apparatus, but it has performed its work admirably, and has never given us any trouble.

TABLE II.—*Ballistic Galvanometer.*

Length of needle = 4·8 cm. Sect. area = ·0726 sq. cm.
Period = 3·8 seconds.
Resistance = 69·6 B.A. ohms at 20deg.
Max. angle of deflection = 9deg.

My audience must remember that all these experiments were carried out in engineering works, and not in a laboratory, and this fact made us anxious to eliminate every source of error. We had to devise a ready method of standardising the galvanometer every time we used it, as motors and dynamos in the immediate neighbourhood are not conducive to constancy in the earth's field.

We therefore made a solenoid of length 120 cm. and diameter 3 cm. Its length being great compared with its diameter, the field at its centre could be accurately calculated from the well-known formula

$$H = \frac{\cdot 4 \pi C N}{l},$$

where C is current in amperes, N the number of turns, and l the length.

Assuming that the permeability of the broomstick on which the solenoid was wound to be the same as that of air

$$H = B$$

we thus get the number of thoms per unit of area at the centre of the coil.

The secondary, wound inside the solenoid in a groove in the broomstick, had 1,000 turns of very fine wire. Its average area was 5·0 sq. cm.

$$H \times \text{area} = \frac{\cdot 4 \pi C N}{l} . a$$

gives the induction cutting the secondary.

This broomstick standard thus gives us a means of calibratin our galvanometer as well as standardising it.

The theory of the ballistic galvanometer given in text-books says, that the induction is proportional to the throw, under certain conditions, one of which is that if there is damping, corrections must be made by means of a "logarithmic decrement." We did not quite know what a logarithmic decrement was, and so we preferred to try whether our scale was a straight line, by going to the *fons et origo* of all knowledge, experiment. We first proved by experiment that

$$\theta \propto \frac{1}{R}$$

if **B** × area is kept constant; where θ is the throw, R the resistance of the circuit, and **B** the induction density. Then we took a curve of **B** and θ for constant resistance and turns, and this curve cannot be distinguished from a straight line.

If, therefore, all deflections are taken with the same resistance in circuit, the formula is

$$\theta = \frac{a n}{R} (B \times \text{area})$$

where a is a constant depending on the galvanometer.

Owing to the variation of the amount of damping with the resistance of the secondary circuit, this formula is not true (except at the resistance at which the galvanometer was standardised), unless the damping be properly allowed for.

Deflections taken at various resistances can be made comparable with one another, by substituting for them uniformly the value they would have had, if some fixed resistance (infinity for convenience) had been in circuit.

A curve of coefficients, by which throws at various resistances must be multiplied in order to reduce them to "throw on open circuit," is easily obtained.

A fixed impulse is given by means of an external coil by tapping a key, and the deflection noted for open circuit, and for various resistances. The damping increases as the resistance of the circuit decreases, and the percentage difference from the throw at infinite resistance is thus obtained. This curve is shown in Fig 2. By means of it all throws can be reduced to throw on open circuit by multiplying by the required percentage. The curve is a rectangular hyperbola.

We are now prepared to standardise the galvanometer.

Since $$\theta = \frac{a\ n}{R} (B \times \text{area}),$$

the induction $= B \times \text{area} = \dfrac{R\ \theta}{a\ n}$;

whence we see the $\dfrac{1}{a}$ or g, the galvanometer constant is to be obtained. Now,

$$g = \frac{1}{a} = \frac{R\ \theta}{n\ B \times \text{area}},$$

and thus one deflection from a known **B** in the broomstick gives the required constant.

Any mutual induction coil may be standardised by means of the solenoid, and used as a standard in place of the somewhat clumsy broomstick.

In our "Mutual Inductioner," 1,273 thoms cut the secondary for 10 amperes in the primary. Everything was now ready, except that all-important item in a research, the elimination of "niggers." I may mention some of these, in case any of you ever have to investigate force-induction curves.

It is necessary to break the primary *very* sharply. We had much trouble from double-breaks until we made a "jumper," in which a copper wire filed to a point was pulled from a mercury cup by elastic. This arrangement is perfectly satisfactory.

Bad contacts in the secondary circuit are a fruitful source of error when working with low resistances. We have made a rocking mercury-cup switch, which when put over to the left, throws the ballistic galvanometer into circuit, and when over to the right short-circuits the galvanometer, and puts the remainder of the circuit on to the bridge, so that its resistance can be taken if necessary before or after each deflection, since the resistance alters by heating. To avoid these errors, wind many turns of secondary, so as to have *large* resistances in circuit; in this case the heating of a secondary of a few ohms does not matter.

A great many errors may be due to the currents in the primary circuit affecting the ballistic galvanometer directly. We leave our leads long, and can then raise, lower, or coil them up, till currents in them do not affect the galvanometer. This point is most important, especially with large primary currents. These "niggers" having been discovered and eliminated, we were in a position to begin our research.

I have entered into a lengthy and detailed description of the method employed, as it is novel, and presents very great advantages. I have thought it better to be too precise rather than not precise enough; for it is generally my experience that it is exactly the information you wish most to have which is omitted. For instance, in Dr. Hopkinson's classic paper, the actual observations from which the curves are taken are not given, and from the scale of these the lower parts are difficult to trace.

(To be continued.)

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CAMBRIDGE.

Elsewhere we give the last report of the Electric Lighting Sub-Committee, which is an interesting though by no means an inspiriting document. We have previously commented upon the Cambridge lighting, and have been informed that our remarks were too hard upon the engineer. We humbly apologise to that gentleman, being now almost convinced that the Archangel Gabriel could not work harmoniously with such a sub-committee as this report points to at Cambridge. For the present we shall direct attention to one point only. The whole report is before our readers, and they will be able to judge its value. One clause of the report is a specimen of the concentrated essence of bumbledom wisdom :

"The sub-committee made enquiry more especially as to the expenditure on coal and labour. It seems that the coal consumed for each unit sold was about 23·4lb., and cost 1·133d. This large consumption is due to the fact that the turbines in use at the Newcastle station are of the old type, and require a larger expenditure of steam per horse-power than other engines, and this tells in an especial degree during the hours when the load on the machines is light. In the improved form which the sub-committee saw at Mr. Parsons's works at Heaton the turbines are steam-jacketed, and the admission of steam is made intermittent at less than full load. These two changes are said to effect a large saving of steam. And when, in addition, the machines are worked with a condenser, there will be a saving, according to the estimate of Mr. Parsons, of 35 per cent. at least. If this should prove to be the case, as the sub-committee believe to be likely, the consumption of steam per horse-power in a turbine will be about the same as in a Willans engine of the same power at full load, and probably much less at light load."

This is, as we say, the concentrated essence of utter rubbish. Fancy a committee of sane men accepting "are said," "if," and "should," in lieu of actual facts! Willans will show engines doing what he says they will do, and Parsons ought to have shown the committee, or rather the committee ought to have insisted upon seeing, the turbine engine working under these conditions of economy. The cost of 23·4lb. of coal at Newcastle is 1·133d., but the committee carefully ignore the cost at Cambridge. The committee has evidently imbibed in some manner or other the ridiculous view that the "initial" outlay is *the* important point. As a matter of fact, a thousand pounds or more may with great advantage be spent initially to save in the constant cost of maintenance. Is it true that Crompton gets his unit for between 11lb. and 12lb. of coal, or something like one-half of the quantity mentioned in this report? If this is so, a saving would be effected on an output of 200,000 Board of Trade units of some £400 or £500 per annum. Now, £500 provides a 5 per cent. dividend on £10,000, or a 10 per cent. dividend on £5,000, and according to our view, an initial expenditure of one or two thousands of pounds to effect this saving would be an expenditure worth incurring. The Town Council of Cambridge began wrongly, and is continuing in the wrong way. Had the question been a sewage scheme, or a water works, or a gas works, a competent engineer would have been engaged to make plans and draw up a specification. This is the proper way also in electric lighting. Our advice would be, commence *ab initio.* Engage, say, Hopkinson, Kapp, or Kennedy to prepare plans and specifications, instructing, however, the gentleman engaged to specify dynamos, engines, etc., under given conditions for economy, etc., but of no special make. Advertise for tenders to be sent in upon the plans and specifications so prepared, give the contract upon the advice of the engineer, and make him the responsible party to see that the work was properly carried out.

The action of town councils in electric lighting matters is unbusinesslike, and the sooner a change is made the better. The asking for and getting a report upon half a dozen contractor-engineers' tenders savours more of childish than sapient action. Each tenderer specifies a different system, and therefore the tenders are not based upon the same features. We absolutely deny the capacity of any engineer to give a satisfactory report under these conditions. The result is a compromise. He likes this suggestion in this tender and that suggestion in that tender, and tries to embody the special things that strike him in his report. Result: patchwork—a Joseph's coat, and the maker of the coat incurs the opprobrium of his fellows. Then the present system gives rise to all kinds of chicanery. Men who are as ignorant of practical work as Indians from the backwoods come to the front, because of the wheels within wheels. Cambridge is doing a grand work in pointing the moral to the tale we have so long endeavoured to enforce. The names such as above mentioned are those of competent men, who could and would do the work required thoroughly and well. It will be seen that the consideration of the report has been deferred.

ELECTRICITY IN MILLS.

A great field is open to electrical engineers, not only in mill lighting, but in utilising the spare power of large mills for all kinds of work by means of electric motors. This can take place in two ways: either the present transmission by shafting can be made more economical, or the extra power of the engine can be employed in useful additional facilities. It is very little realised what a great loss of power often goes on in large mills, where sometimes as much as 20, 30, or even 50 per cent. of the total indicated horse-power is wasted in overcoming the friction of shaftings. If the mill owner can be shown how to utilise this wasted power usefully, there is one field for the electric motor. Where spare power can be obtained from the engine, the addition of a dynamo with sundry motors and appliances will prove extremely useful. There are several directions in which motors in mills can be profitably used—in the addition of further machinery at some little distance, or in outworks having no engines of their own; by the addition of small mill tramways, exceedingly useful for transport of goods; by the introduction of machine tools for special purposes; by the employment of electric cranes or electric lifts; and for the running of water-force pumps for boiler, safety, trade, or household use. Engineers are beginning to recognise the advantages of the electric motor, and illustrations of a model installation, embodying the utilisation of spare power of large mill engines, for all and sundry purposes, such as we have hinted at, would doubtless bring home the advantages still further to that large body of mill proprietors in our manufacturing towns, and result in much business for electric motor makers.

ELECTRIC RAILWAYS.

M. J. J. Heilmann has recently presented to the Société des Ingenieurs Civils a system of combined steam and electric traction, embodying, he claims, the advantages of both, and applicable to ordinary railway lines. He bases his researches upon experiments carried out by M. Desdouits on the French State railways, with reference to the resistance of the air to trains at high speed. These experiments are stated to have shown that a high-speed locomotive sometimes consumes as much as half its own power in overcoming air friction. To avoid this loss M. Heilmann proposes to enclose an electric locomotive in a smooth envelope, shaped with a prow like a ship. Bogie carriages would be used, and the space between each would be also covered in. The weight of the train would be 170 tons for a locomotive, tender, and three bogie carriages, instead of 150 tons as at present. In spite of this difference both the speed and economy, it is calculated, would be greater. The peculiar part of M. Heilmann's scheme is that he proposes to have an electric motor for each carriage axle, worked from a dynamo driven by economical triple-expansion engines carried by the train. In spite of the double transformation, and allowing a large part for the unforeseen, M. Heilmann, basing his figures on electrical engineering practice, looks for a gain of 15 per cent. in fuel. M. Heilmann has prepared a complete scheme, including the employment of a Rechniewski dynamo of 395,000 watts, and four motors each of 40 h.p. Considerable advantages are looked for on account of quick starting, greater equalisation of friction, absence of skidding, and ease of running, besides the economy due to lessening friction and use of triple-expansion engines. We are afraid it will be some time before railway engineers take kindly to the idea, but it certainly would be interesting if M. Heilmann could induce any of the continental railway companies to give his scheme a trial.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING, MEMBER.

(Continued from page 488.)

10. It is easy to treat in the foregoing manner another case slightly more complicated.

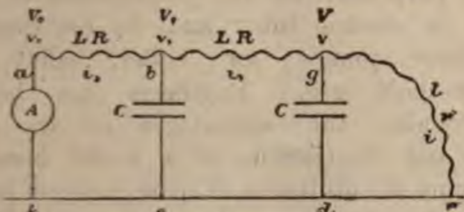

FIG. 7.

Let the inductive line $a\,b\,g\,f$, Fig. 7, be divided into three sections, $a\,b$ and $b\,g$ having each resistance R and inductance L, and the section $g\,f$ having r and l for similar quantities. Let condensers of capacity C be inserted in b and g. If v and v_1 are the potentials at any instant of the condenser terminals, and i, i_1, and i_2 the instantaneous currents in the sections of the line, and I, I_1, and I_2 the maximum values of these periodic currents, it is not difficult to show, with our former notation, that

$$v_1 = \frac{I}{Cp}\Big((B\,a + A\,b)\sin p\,t + (B\,b - A\,a + 1)\cos p\,t\Big) \quad (2i)$$

but

$$i_2 = i_1 + C\frac{d\,v_1}{d\,t},$$

and

$$i_1 = I\,(a\sin p\,t + b\cos p\,t \quad . \quad . \quad . \quad (22)$$

by (12). Hence we have

$$i_2 = I\,\{(Aa - Bb + a - 1)\sin pt + (Ba + A\,b + b)\cos p\,t\} \quad (23)$$

from which we deduce that the ratio of the maximum currents I_2 and I_1, in the first and second sections of the line is given by the equation,

$$I_2 = I\sqrt{(\overline{A+1}^2 + B^2)(a^2+b^2) + a\,b\,\overline{A-B} - 2\,a\,\overline{A+1} + 2\,B\,b + 1} \quad (24)$$

and in like manner the ratio of the maximum values of the potentials V_0 and V_1 can be obtained.

It is possible also to show that for certain critical values of L, C, and R, the potentials V_0, V_1, and V, at the terminals of the alternator and at those of the condensers, progressively increase, as well as the currents in the sections of the line. Cases of this kind, beyond a single condenser, are best treated as Mr. Blakesley has done—by geometrical methods.

11. In the limited case of a condenser charged by an alternating E.M.F. through an inductive circuit, we may arrive at a direct analytical solution of the relation between the coefficients of induction and capacity of the system and the mean square of the charging current, and of the potential difference at the poles of the condenser or at those of the alternator, as follows: As before, let V_0 and v_0 stand for the maximum and instantaneous values of the potential difference at the poles of the alternator; let V^1 and v_1 be the same quantities at the terminals of the condenser; and let I and i be the same for the current flowing into the condenser having a capacity, C, whilst the line connecting the condenser with the alternator has an inductance, L, and a resistance, R. We have then, by fundamental equations, the following relations:

$$L\frac{d\,i}{d\,t} + R\,i = v_0 - v_1 \quad . \quad . \quad (25)$$

$$i = C\frac{d\,v_1}{d\,t} \quad . \quad . \quad . \quad . \quad . \quad (26)$$

Also, let $v_0 = V_0 \sin p\,t$, and hence

$$i = I\sin(pt + \theta),$$

where θ is the angle of lag of current behind the impressed E.M.F.

Eliminating v_1 from the above equations, we have,

$$L\frac{d^2\,i}{d\,t^2} + R\frac{d\,i}{d\,t} + \frac{i}{C} = p\,V_0\cos p\,t\,. \quad . \quad . \quad (27)$$

or since, for simple periodic currents, $-\,p^2 = \frac{d^2}{d\,t^2}$, we have,

$$\frac{d\,i}{d\,t} + \frac{1 - C\,L\,p^2}{C\,R}\,i = \frac{p\,V_0}{R}\cos p\,t \quad . \quad (28)$$

This equation is of the form,

$$\frac{d\,i}{d\,t} + P\,i = Q\cos p\,t,$$

the solution of which is known to be

$$i = \frac{Q\,P}{P^2 + p^2}\cos p\,t + \frac{Q\,p}{P^2 + p^2}\sin p\,t\,;$$

and an easy transformation gives us, therefore, the solution for the particular case in hand as

$$i = \frac{(1 - C\,L\,p^2)\cos p\,t + C\,R\,p\sin p\,t}{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}\,C\,p\,V_0\,. \quad (29)$$

This can be written also,

$$i = \frac{C\,p\,V_0}{\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}}\sin(p\,t - \phi). \quad . \quad (30)$$

and the maximum value of i—viz., I—is therefore,

$$I = \frac{C\,p}{\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}}\,V_0 \quad . \quad . \quad (31)$$

This gives us the mean square, or dynamometer, value of the current I flowing into the condenser in terms of the mean square value of the potential difference of the poles of the alternator and the coefficients C, L, R, and p. If $C\,L\,p^2 = 1$, then the value of I reduces to $\frac{V_0}{R}$; in other words, for this particular value of the relation between the inductance and the capacity the whole system of inductive charging line and condenser acts as if it were a non-inductive conductor of resistance, R.

We see also that this equation (31) can be made use of to determine L from observed values of I_1, V_0, C R, and p, or else C when L is known. The value of the mean inductance of the line is given by the equation,

$$L = \left(\frac{1}{C\,p^2} - \frac{1}{p}\sqrt{\frac{V_0^{\,2}}{I^2} - R^2}\right) \quad . \quad . \quad . \quad (32)$$

which gives L in terms of observable quantities.

The current at any instant flowing across the dielectric of the cable may be spoken of as the condenser current. It is always in magnitude equal to the product of the capacity of the condenser and the time rate of change of the mean potential difference, v_1, of its surfaces. It follows that in the case of simple periodic currents the square root of the mean square of this current, I, which is what we measure with a dynamometer, is equal to the product of the square root of the mean square of the condenser plate potential difference, V_1, and the quantity, C p, where C is the capacity of the condenser, and p, as usual, is 2 π times the frequency, or $I = C\,p\,V_1$. This follows at once from equations (19) and (31). The value of the potential difference at the terminals of the condenser, as measured, say, by an electrostatic voltmeter, is therefore determined by the magnitude of the condenser current flowing into it, as measured by a dynamometer when the frequency of the current is known.

12. The writer witnessed some experiments made in the Standardising Laboratory by Major Cardew, in which the above measurements were carried out. A condenser of ⅓ microfarad was joined across the poles of an alternator, a Thomson deci-ampere balance was put in the charging circuit, and a Thomson multicellular electrostatic voltmeter across the terminals of the condenser. The readings of the voltmeter, V_1, and of the ampere balance, I, were taken simultaneously, with the following results.

---

[*] Paper read before the Institution of Electrical Engineers, May 7, 1891.

Frequency of current, n.	Volts across condenser poles, V_1.	Charging current in amperes, I.	
		Observed.	Calculated.
103	360	·132	·116
103	396	·145	·128
103	493	·175	·160
103	583	·200	·189
90	481	·150	·136
90	598	·187	·170

For the frequency $n = 103$, $p = 2\pi n = 647$, and for $n = 90$, $p = 565$.

Hence, since the condenser capacity, C, = ·5 microfarad = 5×10^{-7} farads, we have as the values of C p for the respective speeds $3{,}235 \times 10^{-7}$ and $2{,}825 \times 10^{-7}$, and the values of the condenser current are calculated from the relation $I = C p V_1$. The calculated values of the currents are all lower than the observed, and in about the same ratio—viz., about 10 per cent.; but the speeds of the alternator, and, therefore, the current frequencies, were not known with a degree of accuracy sufficient to enable it to be determined how far the agreement of observation with theory is complete.

13. The relations between the capacity and self-induction necessary to bring about an increase of pressure at the condenser terminals when an alternator charges a condenser are well displayed by the use of a clock-diagram of E.M.F.'s. Such diagrams have been given by Mr. Kapp in some recent papers, and the particular one here given is practically the same as one given to me by Major Cardew, who has also examined this particular problem. The following mode of regarding it will be found to be an easy one.

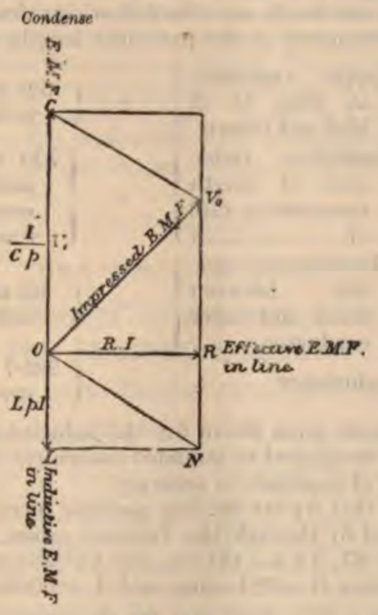

Fig. 8.

Construct a clock-diagram of E.M.F's., see Fig. 8, for the simple case of a condenser charged through an inductive line by a constant harmonic impressed E.M.F. Lines drawn radially from a point, O, in Fig. 8 represent the maximum values of various E.M.F.'s. Let O V_0 be the maximum value of the impressed E.M.F. at the dynamo terminals, and O C that at the condenser terminals; I the maximum current in the line. Take any line O R to represent the effective E.M.F. in the line, and therefore equal to the product R I, where I is the current charging the condenser, and R is the resistance of the line. From R draw R L at right angles to O R, and let R L be set off equal to L p I; L being the inductance of the line, and p being, as usual, 2π times the frequency of the current. Note that when a quantity varies harmonically the product of p, and its maximum value gives us the maximum value of its time rate of change, or time differential, whilst the quotient of its maximum value by p gives us the maximum value of its time integral. Accordingly, O L, which is made equal to L p I, represents the counter E.M.F. of self-induction, or back E.M.F., in the line as far as is due to its own inductance, and is in quadrature with R I as regards phase. Hence the resultant of these two is O N. Next, set off O C at right angles to O R, and in advance of it, and make O C equal to $\frac{I}{Cp}$, that is, to the maximum value of the quotient of the time integral of the charging current by the capacity of the condensr. This gives us the counter E.M.F. of the condenser, or the E.M.F., at the terminals of the condenser, V_1. We have then to take the resultant of this last and O N, which gives us O V_0, and this last resultant is the impressed E.M.F. at the dynamo terminals.

It is necessary to bear in mind that the counter E.M.F., O C, at the terminals of the condenser is in quadrature with the current flowing into it, and in advance of it in phase. The diagram shows us at once that the pressure, $V_0 = O\,V_0$, at the terminals of the dynamo may be less than, equal to, or greater than the pressure, $V_1 = O\,C$, at the terminals of the condenser; and that this is determined by whether the length of the line, $O\,V_0 - \sqrt{O\,R^2 + V_0\,R^2}$, is greater or less than O C. We see that $V_0\,R = O\,C - O\,L = \frac{I}{Cp} - L\,p\,I$, and hence that O V_0 is equal to the square root of $\left\{R^2 + \left(\frac{1}{Cp} - L\,p\right)^2\right\} I^2$. Hence the maximum value of the charging current, I, is given by the value of

$$\frac{C\,p\,V_0}{\sqrt{R^2\,C^2\,p^2 + (1 - C\,L\,p^2)^2}}.$$

Also, we have the same quantity given by the relation $I = C\,p\,V_1$; hence the ratio of V_0 to V_1 is given by the value of the quantity $\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}$, as we have already seen analytically. The clock-diagram has the advantage that it shows us at once the various lags, and gives explicitly to the eye a proof that a gradual increase in the value of the inductance, L, from zero upwards is accompanied by a progressive decrease in the value of the terminal pressure, V_0, at the dynamo, as compared with the terminal pressure, V_1, at the condenser.

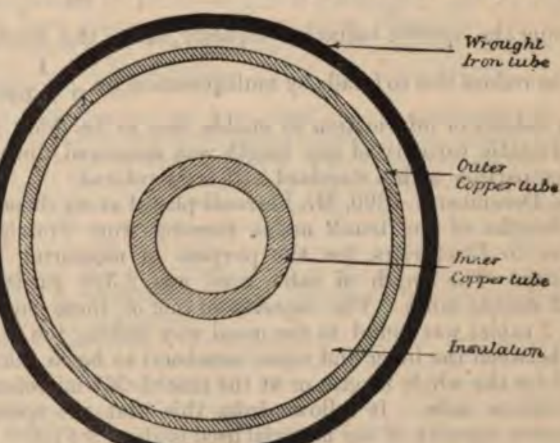

Fig. 9.—Section of Ferranti Trunk Main (full size).

14. In the next place, I wish to place before you an analysis of some experiments which have been made on great lengths of the Ferranti trunk mains between London and Deptford, and which illustrate these principles in a remarkable manner. We are all aware that these cables are concentric cables, and that they possess, accordingly, very measurable electrostatic capacity. The following are the data of the dimensions of these cables, kindly given to me by Mr. Ferranti. The inner conductor, or inner member, is a copper tube (see Fig. 9) of which the inside diameter of cross-section will be called D_1, and radius R_1, and the outside diameter D_2, and radius R_2. The outer conductor, or member, is a copper tube of which the inside diameter will be called D_3, and radius R_3, and its outside diameter D_4, and radius R_4. The insulation between the inner and outer members is compressed brown paper and black wax. The values of the diameters and radii of cross-section of these tubes are as follows (see Fig. 7).

$$D_1 = {}^9/_{16} \text{ of an inch} = \cdot5625\text{in.}$$
$$D_2 = {}^{13}/_{16} \text{ ,, ,,} = \cdot8125\text{in.}$$
$$D_3 = 1{}^{27}/_{32} \text{ ,, ,,} = 1\cdot8437\text{in.}$$
$$D_4 = 1{}^{15}/_{16} \text{ ,, ,,} = 1\cdot9375\text{in.}$$

Hence we have—

$$R_1 = \cdot281 \text{ in.} \qquad R_1^2 = \cdot0789$$
$$R_2 = \cdot406 \text{ in.} \qquad R_2^2 = \cdot1648$$
$$R_3 = \cdot922 \text{ in.} \qquad R_3^2 = \cdot8500$$
$$R_4 = \cdot969 \text{ in.} \qquad R_4^2 = \cdot9389$$
$$R_2^2 - R_1^2 = \cdot0859\text{in.} \qquad R_4^2 - R_3^2 = \cdot0889$$

Area of cross-section of inner member =

$$\pi\,(R_2^2 - R_1^2) = \cdot2689 \text{ sq. in.} = \tfrac{1}{4} \text{ sq. in., nearly.}$$

Area of cross-section of outer member =

$$\pi\,(R_4^2 - R_3^2) = \cdot2793 \text{ sq. in.} = \tfrac{1}{4} \text{ sq. in., nearly.}$$

Also, we have—

$$\frac{R_3}{R_2} = 2\cdot270, \qquad \frac{R_2}{R_1} = 1\cdot444, \qquad \frac{R_4}{R_3} = 1\cdot051,$$

$$\frac{R_1^2}{R_2^2 - R_1^2} = \cdot9185, \qquad \frac{R_4^2}{R_4^2 - R_3^2} = 10\cdot561,$$

$$\frac{2\,R_1^4}{(R_2^2 - R_1^2)^2} = 1\cdot6872, \qquad \frac{2\,R_4^4}{(R_4^2 - R_3^2)^2} = 223\cdot068,$$

$$\log_e \frac{R_3}{R_2} = \log_{10} 2\cdot27 \times 2\cdot3026 = 2\cdot3026 \times \cdot35603.$$

These quantities are required in the calculation of the inductance of the cable.

If the specific inductive capacity of the dielectric were a definitely known quantity, it would be, of course, easy to calculate from the above figures the capacity of one mile run of the cable by the formula,

$$\text{Capacity in electrostatic units} = \frac{K\,l}{2 \log_e \dfrac{R_3}{R_2}},$$

K being the specific inductive capacity, and l the length; and to reduce this to farads by multiplication by $\dfrac{1}{9 \times 10^{11}}$.

In default of information to enable this to be done, the electrostatic capacity of one length was measured directly by comparison with a standard half a microfarad.

On December 5, 1890, Mr. Ferranti placed at my disposal two lengths of the trunk mains running from Trafalgar-square to Blackfriars, for the purpose of measuring the capacity. The length of cable used was 2,399 yards, or 1·363 statute miles. The capacity of one of these lengths (No. 3 cable) was found in the usual way (taking the capacity between the inner and outer members) to be ·5 microfarad for the whole length, or at the rate of ·367 microfarad per statute mile. It follows from this that the specific inductive capacity of the material used is about 3·4 (air = 1). Using the other cable (No. 4), the copper resistance was found to be ·324 legal ohms, or ·328 B.A. units per statute mile, reckoning the resistance per mile run of the cable, and including, therefore, both the inner and outer conductor. The insulation resistance between the inner and outer member of the first cable was found to be at the rate of 720 megohms per mile. The instruments used in taking these measurements were a half-microfarad condenser by Dr. Muirhead, and a legal ohm Wheatstone bridge and megohm standard, kindly lent by Messrs. Elliott Bros. for the purpose. The temperature of the ground on that day was near the freezing point, and Nature saved us the trouble of reducing the values to zero centigrade.

The remaining element required is the inductance of the cable per mile. Fortunately, the form of cable which is the best for practical reasons, is almost the only case in which the inductance can with no great difficulty be calculated with any required degree of accuracy from the dimensions of the cable. Lord Rayleigh has solved for us the problem of the inductance of a pair of concentric conductors placed co-axially. His formula, as given in his paper in the *Philosophical Magazine* of May, 1886, page 385, is as follows, when translated into my nomenclature, and the values of the magnetic permeabilities of the materials all taken as equal to unity:

$$L = \text{inductance per unit of length} = 2 \log \frac{R_3}{R_2} + \frac{2}{R_2^2 - R_1^2}\left(\frac{R_2^2 - 3\,R_1^2}{4} + \frac{R_1^4}{R_2^2 - R_1^2} \log \frac{R_2}{R_1}\right)$$
$$+ \frac{2}{R_4^2 - R_3^2}\left(\frac{R_3^2 - 3\,R_4^2}{4} + \frac{R_4^4}{R_4^2 - R_3^2} \log \frac{R_4}{R_3}\right).$$

The logarithms are all Naperian, and the values of R_1, R_2, R_3, and R_4 may be taken in any units, as only their ratios are required.

The values of the chief functions of the radii of the tubes have been given above, and, making the substitutions, we have for the inductance of one centimetre run of the cable the following value:

$$L = 2 \log 2\cdot227 + 1\cdot6872 \log 1\cdot444 + 223\cdot068 \log 1\cdot051 - (\cdot9185 + 10\cdot561).$$

Remembering that the logarithms here are Naperian, and that the logarithms to base 10 must be multiplied by 2·3026 to reduce them to the Naperian base, we have as a final result of the calculation,

$$L = 1\cdot7755 \text{ centimetres.}$$

Hence, since one statute mile = 160,931·5 centimetres, the inductance per statute mile of the Ferranti cable is 285,734 centimetres = ·0002857 of a henry, or 285·7 microhenrys.

This result will be accurate to just the extent to which the diametrical measurements of the conductors are accurate.

Collecting our results, we have for one statute mile run of the Ferranti trunk main the following values, as deduced from measurements on the particular lengths employed:

R =	Copper resistance at 0deg. C. of lead and return	=	·324 legal ohm per mile.
K =	Insulation resistance of length measured at rate of..................	=	720 megohms per mile between inner and outer conductor.
C =	Electrostatic capacity between inner and outer conductor	=	·367 microfarad per mile.
L =	Inductance	=	285·7 microhenrys per mile.

The formula given above for the inductance per unit of length can be applied to stranded concentric cables with a fair degree of approach to accuracy.

Suppose that we are sending periodic currents having a frequency of 67 through the Ferranti cables, then, if n = frequency = 67, $2\,\pi\,n = 421 = p$, and $4\,\pi^2\,n^2 = p^2 = 177{,}241$.

Hence, since R = ·324 ohm, and L = ·000286 henry, we have $\sqrt{R^2 + p^2\,L^2} = \cdot3455$ ohm for the impedance per mile and we see that at this frequency the impedance exceeds the resistance by about 7 per cent. of the latter.

From the data thus given other functions of the capacity, C, inductance, L, resistance, R, and impedance, I, per mile can be built up, which will be required presently. These are

$$P^2 = \frac{C\,p}{2}\left\{\sqrt{R^2 + p^2\,L^2} - p\,L\right\} = \cdot00001738;$$

$$Q^2 = \frac{C\,p}{2}\left\{\sqrt{R^2 + p^2\,L^2} + p\,L\right\} = \cdot00003597.$$

Hence, also,

$$P = \cdot004168, \quad Q = \cdot005997;$$

$$P^2 + Q^2 = \cdot00005335, \quad \frac{P^2 + Q^2}{I^2} = \frac{447}{10^6};$$

$$(2\,P\,R + 2\,Q\,L\,p) = \cdot004147;$$

$$(2\,P\,L\,p^2 - 2\,Q\,p\,R) = -1\cdot216.$$

All the quantities refer to one mile run of the cable.

15 In the course of various experiments during the laying of the cable it became evident that a conductor

having so considerable an electrostatic capacity behaved in a curious manner under some circumstances when long lengths were connected up to a transformer. This behaviour has been much misunderstood, and much misdescribed. Remarkable phrases have been coined with reference to it, such as "the piling up of the volts," or "packing up of the volts," which are not very lucid descriptions of what really does occur. Ingenious theories have been constructed also to account for phenomena which do not exist. Briefly stated, it appears to be as follows: When an insulated and sufficient length of the cable has its inner and outer members connected to the terminals either of a transformer or of an alternator having an armature of sufficient inductance, it is observed that under these conditions the potential difference between the inner and outer members, measured anywhere along the length of the cable, is generally greater than would be the potential difference of the terminals of that alternator or transformer if the cable were very short, or not present at all. This seems to hold good also when the far ends of the inner and outer members are connected together through a not very small resistance, such as a row of incandescent lamps in series, or a high-resistance voltmeter, or transformer lightly loaded. The cable acts in all apparently as one single condenser would do, and in no case, as far as is known, is there evidence of a continuous rise of pressure along the trunk mains themselves. The pressure at the London end is not found to be greater than at the Deptford end. The condenser effect is increased apparently by increase of length of the main, at least within observed limits, and in all cases the main acts as if it were a condenser bridged across between two parallel mains without capacity. When current flows into the cable there is a flux across the dielectric from inner to outer member which constitutes the condenser current of the mains, and the outflowing current is in general less in magnitude than the inflowing current, although not always necessarily so. The current flowing out at the London end may be called the work current. There is a difference in phase between the work current and the condenser current. The ingoing current is the resultant of the work and condenser current.

(To be continued.)

ON SOME POINTS CONNECTED WITH MAINS FOR ELECTRIC LIGHTING.*

BY WILLIAM HENRY PREECE, F.R.S., PAST-PRESIDENT.

1. I do not propose in the following paper to describe the mechanical details of the various systems of mains adopted in different places to transfer and distribute electrical energy. These, most of us can see for ourselves by personal inspection in the various works now in progress in London, or can read about at our leisure, in the numerous papers that have been recently printed in the technical periodicals and in the *Journal* of our Institution. My object is to extol the "sweet simplicity" of the two-wire system, the practical security of concentric mains, and the unquestionable economy of the high-pressure principle. At the same time, I do not want to be considered an advocate of any one particular method. Engineering works must necessarily be considered a species of compromise. Conditions vary in different localities; difficulties arise in the most unexpected quarters; different ways of surmounting obstacles occur to different minds. What is good for one place need not necessarily be good for another. The independent engineer must keep his mind open; he must master his requirements; he must give every plan his consideration, and choose his best agents, despite the tyranny of the Patent Laws and the susceptibility of inventors. He must, however, be just, and see that merit is rewarded and claims respected.

2. I do not intend to discuss overhead wires. I consider them, for high-pressure electric light circuits, an abomination, especially as it is easy to show that ultimate economy is in favour of the underground system. It is only the first capital expenditure that favours overground mains; safety, freedom from accident, ease of repair, and renewals are all the other way.

3. Broadly, the different underground systems in use may be classed into those which are fixed and those which are movable.

As a type of the first, I will instance the Ferranti concentric mains, that are buried solidly in the roadways, embedded in asphalte in wooden troughs, and which are inaccessible except by excavation; and as an example of the second I will take the ordinary telegraphic method of burying cast-iron pipes, with occasional boxes, in and out of which cables new and old can be drawn at pleasure, and where the conductors are always accessible for the rapid removal of incipient faults should they develop themselves, and removable for enlargement should the system grow.

4. Again, we must divide the systems into high and low pressure, for under these two heads we have to consider not only the all-important questions of insulation and of finance, but those of security to person and to property. The line of demarcation between high and low pressure has been defined by the Board of Trade to be 300 volts; but in what follows, whenever high pressure is mentioned, about 2,000 volts is meant, and low pressure implies about 100 volts. There is one case only in this country where extra high pressure is used, and that is by Mr. Ferranti, whose adoption of 10,000 volts is regarded by so many with fear and horror. This voltage is, however, going to be exceeded this summer by the exhibition authorities at Frankfort, who are going to draw 300 h.p. from the River Neckar, at Lauffen, 112 miles away, by a pressure of 27,000 volts.

5. The only limit to the use of extra high pressures, or to the voltage employed, is the efficiency, economy, and durability of insulating materials.

First and cheapest on the list is air, which, when dry, is the most perfect insulator known—its specific resistance being, in fact, immeasurable—which has the lowest specific inductivity, and therefore is taken as unity, but which cannot resist electric stress, and through which the sparking distance has a very poor figure of merit. The breakdown stress, or sparking distance, of dry air at ordinary atmospheric pressures may be taken to be for—

Direct currents .... 9,200 volts per centimetre,
Periodic alternating currents 6,000 ,, ,,

between a disc and point.

Air is, moreover, hygroscopic, and very variable in its qualities; but there is no evidence that the variation of its saturation point affects its resistance or its inductivity, excepting that it tends to coat with moisture glass, porcelain, and other insulating supports, which are essential to keep up metallic conductors in position when it is used as an insulator, if their temperature falls below that of the air. The use of air was inaugurated by Mr. Crompton in Kensington, and his example has been followed by Latimer Clark, Muirhead, and Co. in St. James's, by Prof. Kennedy in Westminster, and by Prof. Robinson in St. Pancras. It has also been followed in Paris and in Germany.

6. Guttapercha has been used almost exclusively for submarine cables, and for telegraphic underground wires in Europe; but owing to its scarcity and its high price it is rapidly being replaced by other materials, and, excepting in Paddington (Great Western Railway), where it was laid down by the Telegraph Construction Company, I do not know of its use for electric light purposes. It does not stand exposure to variations of temperature or of dryness. It is durable only in water, and even if it were plentiful it is doubtful, if it were practical, for electric light purposes.

7. Indiarubber is more practical. Modern improvements in vulcanisation have brought it within the scope of the engineer and the range of finance. The addition of a small quantity of sulphur, subjected to high temperature, produces a new form of rubber, which makes not only an admirable insulator, but a waterproof, homogeneous, compact, and apparently durable compound. Our experience of this latter quality is, however, limited at present. The cables of this class manufactured by the Silvertown Company have justly acquired a high reputation, though several other firms are competing with them on equal merits. The weak point is in the jointing, which, unless properly done and thoroughly vulcanised, admits into the system numerous points of danger, which, sooner or later, will occasion engineers in charge many minutes of anxiety and worry. Compound rubber cables are used exclusively by the Metropolitan Electric Supply Company and by the House-to-House Electric Light Company, for their mains distributing high-pressure alternating currents. I am assured by both companies that up to the present time not one single defect has developed itself in their mains.

8. Bitumen is a mineral product of a pitchy character, imported into this country principally from Trinidad. The late Lord Cochrane tried hard to introduce it as an insulating medium, but it remained for the enterprising firm of Callender to make it a real commercial commodity. When purified, refined, and vulcanised it makes, combined with some vegetable fibre like jute, a tough elastic coating, proving it to be an active competitor of compound rubber. When used in its crude state it forms a solid mass, in which the more refined "bittite" can be embedded in an immovable and apparently indestructible and unassailable bed.

9. There are various waxes—paraffin, ozokerit, and other hydrocarbons—which have a high specific resistance and a low

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* Paper read before the Institution of Electrical Engineers, May 7.

specific inductivity, that have been much used; but the most practical use of these materials appears to be their combination with brown paper, which has been introduced by Mr. Ferranti in his Deptford mains.

10. The refuse of crude petroleum—that is, petroleum after all the spirits, illuminating and lubricating oils, and waxes have been distilled or expressed—a thick, heavy black mass, liquifiable under high temperature, but almost uninflammable, and eminently adapted to resist high temperatures—makes an admirable insulating compound of very high specific resistance and comparatively low specific inductivity. It is the material used by the Fowler-Waring Company, and destined to enjoy a profitable career.

11. Heavy resin oil is an admirable insulator, filling, when hot, all the pores of vegetable matter like jute and cotton immersed in it, excluding all air and moisture from the conductor, having a very high resistance and a very short sparking distance, but, above all, being viscid and movable, so that any puncture is at once filled up by its own mobility, so that any fault occasioned by piercing is instantaneously self-cured. Oil has such excellent merits that it has been proposed by Johnson and Phillips to bury in it high-pressure alternate-current transformers. Heavy oils discard water, owing to their density. They are inoxidisable, and therefore practically indestructible. Many failures in the use of oil as an insulator in the past have arisen from the use of oils of too low specific gravity.

12. There is one objection to most of these mineral hydrocarbons—viz., that they require to be encased in lead; but oil has this advantage, that it can be used in iron pipes in the method adopted by Brooks. Lead covering is expensive, and it adds seriously to the weight of the cable, so as to render more difficult its handling and drawing in and out. On the other hand, lead adds materially to the life of the cable. I have in my possession samples of lead-covered wire which was buried in 1844, and in which the conductor and insulating medium are now as perfect as when made. Lead, however, in some localities, especially in decaying vegetable matter, is itself attacked. When, however, properly protected, it ought to last for centuries. The lead used by the Romans to distribute water in Pompeii is still visible. Lead-covered cables are very largely used in America, Germany, and France, and their employment is rapidly extending in England.

13. All these materials, excepting air, are equally applicable for high and for low pressures, the thickness only has to be increased with the pressure; but we have yet to know what influence the rapid reversals of high-pressure alternating currents have upon the molecular structure of the material. The difference in the striking distance in air shows that the stresses in the two cases of direct and alternating currents are very different. Time alone will give us the experience we want as to the effect of these stresses on the texture of the dielectric used. It is this absence of experience that causes so much want of confidence in the use of extra high pressures.

14. The operation of Sir William Thomson's law, the relative economies of the two-wire, three-wire, and five-wire modes of distribution, the comparative cost of high and low pressure, have been so frequently discussed, and are so thoroughly well known, that they need no description here. Everyone will admit that as we increase the pressure driving the currents, we can diminish the size of the conductor; and although we have to increase the relative thickness of the insulating medium, the actual quantity used remains practically the same. Hence high pressure means great economy in copper. The future of electric lighting is a financial question; its practicability and efficiency are beyond doubt. The lion share of the capital necessary for the extension of electric lighting over a district is required for the mains and conductors; an important item in working expenses is in their maintenance. Hence, this is now the field for the exercise of economy. If we can reduce the cost of distribution and its upkeep by 50 per cent., we should be able to supply light by electrical energy more cheaply than by gas. It is a pity that some of that redundant mental energy which is endeavouring to raise the efficiency of dynamos and transformers from 94 per cent. to 95 per cent. could not be transferred to the question of mains, where real advancement and true economy on a considerable scale are much more required.

In Liverpool, Birmingham, and Bradford, low pressure is distributed by the original and simple two-wire parallel system. In Kensington and Westminster low pressure is distributed by the three-wire plan. The London Electric Supply Company, the Metropolitan Company, and the House-to-House Company distribute their high-pressure systems by two wires: but in Rome, where sub-stations are used, the distribution of low pressure is by three wires. In Germany distribution in some places is by five wires, and I have heard it mooted to distribute in Paris by six wires.

15. The points that determine the distribution of low pressure are fall of potential, and number of feeding points and distributing stations. We need not consider the heating of conductors. If we take care of the potentials the waste will take care of itself.

One ton of copper of one square inch sectional area covers a length of 192·3 yards, and its resistance is ·0046 ω. Hence, a length of 220 yards weighs 1·13 tons, and its resistance is ·00527 ω. A pair of such mains will weigh 2·26 tons, and their resistance will be ·01054 ω. One thousand amperes means, therefore, a loss of 10½ per cent. (and one kilowatt is wasted in every 43·4 yards), 500 amperes means a loss of 5¼ per cent., and 237 amperes means a loss of 2½ per cent., in such a circuit when the full load is supposed to be concentrated at the end. If we take a fall of potential of 2½ per cent. in each main, which is the recognised maximum waste at full load allowed to comply well with Thomson's law, it means 474 amperes delivered at 100 volts, or 1,600 8-c.p. lamps served. In fact, we may say that two mains of one square inch copper will serve 1,600 8-c.p. lamps at 220 yards distance; and this appears to be the commercial limit of the two-wire low-pressure distribution. Of course, if we are content to admit a greater waste, this limit of distance can be extended, and the number of lamps to be served can be increased in the same ratio. The exact waste to be allowed is an economical question governed a good deal by the conditions of the problem, financial as well as engineering. Now, if we add another 100 volts at the point of supply, we can deliver the same energy for the same number of lamps with the same loss, at 880 yards; and for every additional 100 volts delivered, we can extend the distance to which the supply can be driven under similar conditions, as the square of the unit distance, 220 yards, for to maintain the same energy the current is diminished in the same ratio. Thus, 2,050 volts will drive the energy required for 1,600 8-c.p. lamps 50 miles if we use mains of one square inch sectional area, and are satisfied to waste only 5 per cent. of the driving energy. Prof. John Hopkinson, F.R.S., showed how,[*] by the use of an intermediate third wire and two dynamos, we could use 200 volts with our present lamps, and therefore we could practically diminish for the same distance the weight of copper used by one-half, or we could make the same weight of copper serve double the distance. The third wire, however, diminishes the effective economy of the plan. Its practical commercial limit appears to be about half a mile; and its disadvantages to be, more dynamos to work, and considerable complication to adjust and regulate the equilibrium of lamps on the circuit.

The five-wire system, which is in use in Germany, enables us to use 400 volts at the point of delivery; and this, again, enables us to extend our area of supply with the same weight of copper to one mile, but with more dynamos, and with more regulation and balancing, and therefore with more complication.

There is no practical limit to the high-pressure system; 10,000 volts will drive energy from Deptford to London on two mains of one-quarter square inch section to serve 50,000 lamps, and 27,000 volts will drive 300 h.p. 112 miles, from Lauffen to Frankfort, on a conductor of ·06 square inch sectional area—*i.e.*, a No. 2 copper wire.

16. But we have to take into consideration the difficulties of the distribution.

On the two-wire system this means one central station for each effective area having a mean radius of 220 yards. On the three-wire system this area can be extended to a mean radius of one-half mile; the five-wire system extends the mean radius to one mile; but with the high-pressure system the area is practically unlimited in extent. When the mains and feeders are at high pressure, and the distribution at low pressure by two wires, we must contemplate sub-stations serving areas having a radius not exceeding 220 yards, if the lamps be uniformly scattered over the area and our waste energy is kept low.

A transformer sub-station is a very simple and cheap structure. It may be excavated underground, or be in a cellar or in a back yard. The instruments are stationary. They require no oiling, nor adjusting, nor handling, nor even tending. They can be buried in oil and suffer no deterioration. They are simple in construction, and should need no repair. Switches to throw them in and out of circuit may be automatic or manual, and can be operated from outside the transformer-room, as is done in Rome.

17. The sub-station high-pressure system has been thoroughly worked out in Rome. Every nest of about 2,000 lamps is served from a sub-station containing a bank of 12 transformers, each of 7½ kilowatt capacity. Means are provided to cut transformers in and out as the load comes on and off. The great waste of the idle transformer is thus prevented, and by banking them in this way only half the total number of transformers is required. Moreover, it enables the most efficient transformers to be used, and always at full load. It is well known that the efficiency of a transformer increases with its size. Mr. Ferranti has already reached 100 kilowatts without reaching a limit to this law. Distribution by two wires on this limited scale is of the most economical and effective kind, and there is no complication of adjustment of current or regulation of pressure. Each sub-station serves, as a rule, in Rome, one block of buildings, so that generally the high-pressure mains alone are underground.

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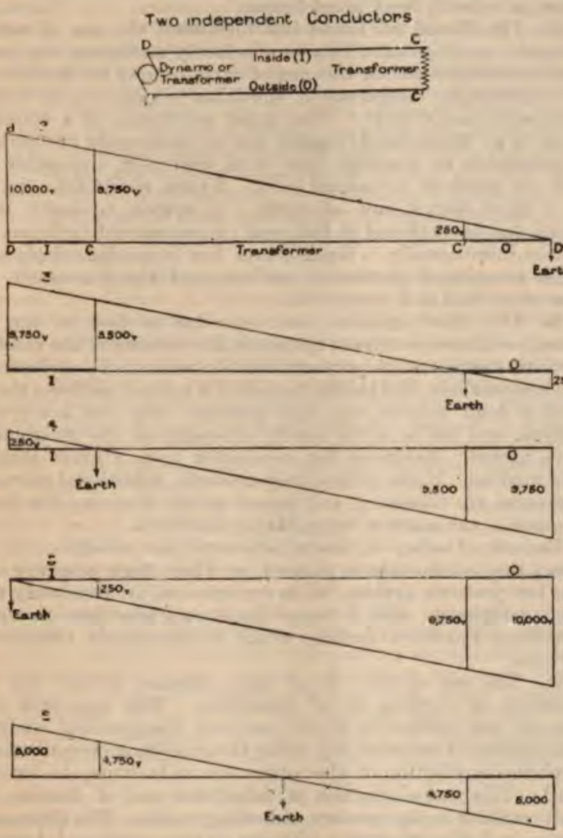
[*] John Hopkinson, Patent No. 3,576, July, 1882.

The pressure is 2,400 volts. The distribution in Rome is by three wires—not, however, for any economical reason, but simply to allow arcs and glow lamps to works on the same network without interference and without waste. The counter E.M.F. of the arc prevents arc lamps from being registered accurately on any of the existing meters, but the three-wire plan enables the arcs to be served separately from the glow lamps. Arc lighting is in great request in Italy, especially for shop lighting.

The chief difficulty the engineer has to encounter, is to know his users and the extent and character of the supply. This is now generally guesswork. It is difficult to estimate the actual load factor. We have to take the gas supply as our criterion, and to judge of the probability of obtaining customers from the character of the residents and occupants of the district.

18. It is impossible to serve economically a wide and scattered district with a mean radius of over one mile by any other means than by high pressure, for we cannot multiply central stations without seriously increasing capital outlay and working expenses; unless, indeed, the density of supply be very great, as it is in some quarters in London and in some of our large provincial cities.



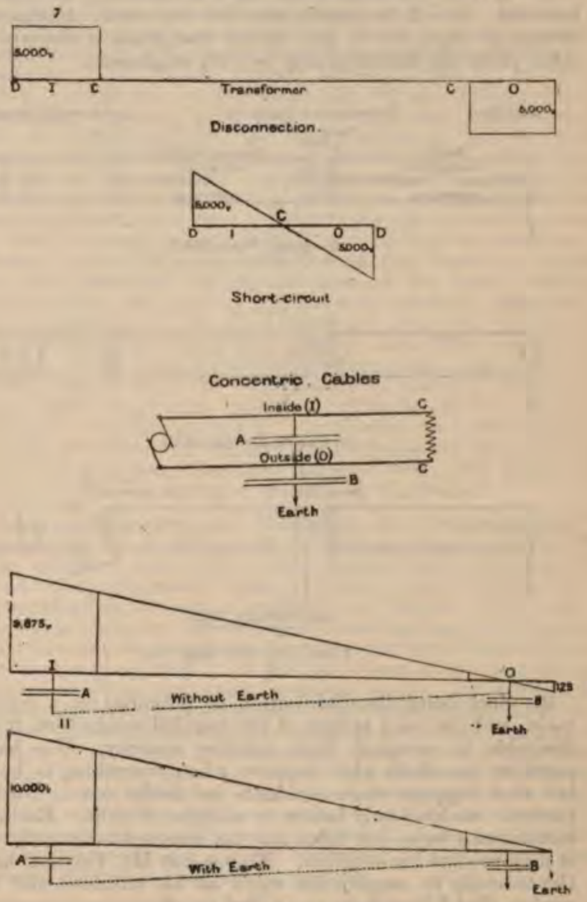
Figs. 1 to 6.

19. Let us assume that we have a wide and scattered district to serve, and that we are going to supply at high pressure, and to distribute by two wires from sub-stations. The problem we have to solve is: What shall be the character of the high-pressure mains and feeders connecting the central station, or stations, and the sub-stations? Shall they be separate conductors or concentric cables? We will also assume that the weight of copper and quality of insulation is the same in each case, and that their prime cost is not materially different, although, as a matter of fact, for the same distance the concentric main, if made of the same materials, costs less than the two separate conductors.

It is therefore a question of adaptability, security, and freedom from disturbance. To study these points, we want to know how the potentials are distributed on such conductors.

If we consider two independent conductors, Fig. 1, lying side by side in the same pipe or conduit, connecting the two poles of the dynamo, D and D', with the transformer, C C', and we call the go wire the inside, I, and the return wire the outside O, then, if we represent the effective resistances at any moment of the transformer by the straight D D' line, Fig. 2, D C can represent the resistance of the inside conductor, C C' that of the transformer, and C D' that of the outside conductor. If the ordinate D *d* represents the positive pressure when at its maximum and the transformer on full load, then, if the pole D' be connected with earth, the slope of the line will indicate the simultaneous pressure at any point of the circuit, and the difference between the ordinates will give the fall of potential between any two points; that is, there is a fall of 250 volts in each conductor, and if the circuit be carrying 50 amperes there will be a waste of 12,500 watts in each conductor. If the line O were in its proper position and direction alongside I, as in Fig. 1, it would be seen that the difference of potentials between any contiguous points is everywhere 10,000 volts.

Now, if the earth be transformed from D' to the negative pole of the transformer, C', the pressure at the similar phase will rearrange itself as shown in Fig. 3; and Figs. 4 and 5 give the same information when the earth is consecutively fixed at the other pole of the transformer and dynamo. Fig. 6 shows the distribution when the centre of the transformer is to earth, or when there is no earth. It will be seen in each case that the fall of pressure remains the same; the difference between the potentials between the conductors remain the same; it is the sign and the difference of potential between each point and the earth that has altered. Fig. 7 shows the distribution when the transformer by some accident is disconnected, and Fig. 8 when it is short-circuited.



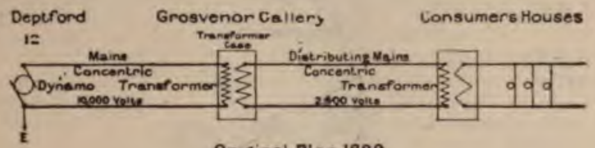
Figs. 7 to 11.

I have not considered the variations of potential due to the rise and fall of the currents, and I have ignored the dynamo, the potentials being those at its terminals. Frequency, inductance, impedance, besides capacity and resistance, enter to complicate matters and to deprive the graphical method of that simplicity which is shown by the figures. But Dr. Fleming has exhaustively dealt with this subject analytically and in a masterly manner.

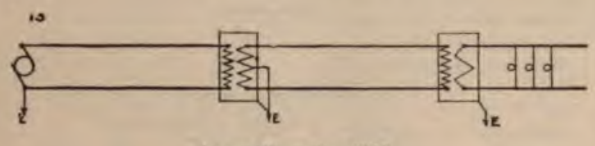
20. Now Mr. Ferranti's mains are concentric, and their capacity must be taken into consideration. Fig. 9 shows these capacities, that between the two conductors being ·35 microfarad per mile, and that between the outer tube and earth being three microfarads per mile. Figs. 10 and 11 show the distribution of pressures when the earth is on and off the pole of the dynamo. The remarkable fact comes out that whether the pole be to earth or not the difference of potential between the outer conductor and earth of a concentric cable is practically the same in each case. It does not exceed 250 volts in either case, and therefore the cable could be handled with impunity while the current was flowing and all connections were right, but if a fault arose—disconnection or short-circuit—then the result might be serious. A long length of perfectly insulated cable with considerable capacity is practically in the same position as though it were connected to earth. The surging in and out of the cable of the electrical quantity dependent on the capacity and the impressed E.M.F., produces the same effect at the terminals as the periodic flow of current through the cable when the distant end is to earth. The effect of capacity is to lower the potential, and when its magnitude is sufficient it reduces the potential of the conductor to that of the earth, for it does not allow time enough for the charge to accumulate. Hence, a

concentric main, whether its outer conductor is connected to earth or not, has its potential reduced practically to that of the earth. The use of the earth is imperative to dissipate the static charge and to secure safety. A permanent and efficient earth makes the cable safe to person, and dangerous to apparatus only, which can be fully protected by fuses. Unless, however, it is most effectively applied, it may become a source of danger to person also, and of disturbance to telephones, for the existence of a variable fault might produce a shifting of potentials which would destroy the security.

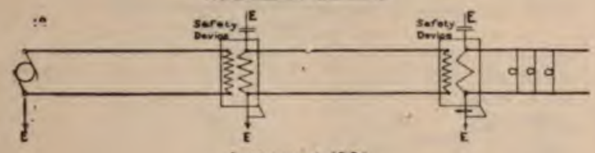
It is very easy by the aid of such diagrams to study the distribution at any phase of the potential, or at any instant of flow. The capacity acts as a kind of break or damper on the currents, and its tendency is to vary the rate of rise of potential, and to flatten the curve of rise and fall of the currents. With direct and intermittent currents it acts as a flywheel, but with alternate currents it acts more as a spring, or as an air cushion in a hosepipe. Its effect with ordinary frequencies is not material, but the rapid alternations of stress and displacement in the dielectric must have a tendency to heat that material. It will be readily seen how the earth dissipates the charge at once, but it also shows that when a disconnection takes place this discharge may be very unpleasant.



Original Plan 1889.



In use November 1890



Authorised 1891.

FIGS. 12, 13, and 14.

21. Such being the distribution of potential on a concentric main, and also on a system of two parallel conductors, it is now desirable to compare their relative security. We have to consider, not alone what happens when everything is in order, but what happens when accidents and faults arise. Nothing is perfect—we have only before us a choice of evils. Earth is the electrician's bane, but there may be circumstances under which it may become his antidote. No one but Mr. Ferranti has had the temerity to employ the earth as his antidote, and I must confess that I have been compelled to effect a compromise with him on the subject. His original form of cable was designed so as to place the outer tube completely to earth, but my own experiments* and his experience have shown that this outer tube must be thoroughly well insulated to prevent the introduction of serious disturbing effects on telegraphs and telephones. In Rome, where Siemens concentric cables are largely used, but without earth, the outer insulator was so frequently pierced, that Prof. Mengarini found it necessary to make the outer insulation thicker and better than the inner. The sudden stoppage of a flow of great energy from any cause must lead to effects analogous to those of momentum, and unless some buffer or cushion is provided, either in the form of a condenser or of the earth, a heaping up of pressure must occur somewhere, and sparking and rupture follow.

22. Mr. Ferranti claims for his concentric mains with the outer conductor earthed at one end, as shown by Fig. 11: 1. Absolute safety in handling by workmen, and freedom from fire risk. 2. Dispersal of the static change accumulated on the conductors. 3. Freedom from disturbance on neighbouring wires.

I can corroborate the last point. We in the Post Office are now quite unaware whether the Deptford mains are at work or not. It was not always so. At first, starting with imperfect cables, the disturbances were very serious.

The compromise effected between the Postmaster-General, the Board of Trade, and the London Electric Supply Corporation is shown by Figs. 12, 13, and 14, which also give some of the changes that have been made.

We allow earth on the outer conductor at Deptford, and at each distributing station, but not on mains other than concentric, or on the house service excepting through a safety device.

With regard to high-pressure alternating-current systems generally, earth cannot be admitted on house wires, because with its use, high insulation is imperative to reduce fire risks, and high insulation cannot always be maintained. Leakage means danger, in spite of fuses and safety devices. Fire and life risks are intensified by bad earths. Good earths are very difficult to secure, and alternate currents do not like earth: that is, the resistance of earth to alternate currents is much greater than that to direct currents.

We can secure safety in houses by: 1. Good materials. 2. Good workmanship. 3. High insulation. 4. Well-designed safety devices. 5. Frequent tests. 6. Incessant personal supervision. 7. *No earth.*

In the wiring of houses, supply companies and corporations cease to exercise responsibility. They deal with confiding customers, irresponsible contractors, untechnical and uneducated employés, and all sorts and conditions of men. Were it not for the Board of Trade to regulate our mains, and the fire insurance companies to regulate our house wires, electric lighting in England would be as dangerous a pursuit as it appears to be in the United States.

23. The Board of Trade has forbidden the use of earth on separate conductors. This is absolutely necessary, for, except with concentric mains, the use of earth on one conductor might be exceedingly dangerous if the other conductor, by fault or otherwise, made earth. The inner conductor of a concentric main is so hermetically sealed, and so thoroughly protected by a succession of coatings, that it is well nigh impossible for a leak to earth to be caused on it. Faults would take the form of a short-circuit, not of earth. A system to earth is one which has been placed at full cock; a permanent fault has been put on intentionally. Equilibrium has been disturbed, and it is the security of the inner conductor of the concentric main that alone makes it acceptable.

24. The chief accident that one has to fear in the high-pressure alternate-current system is the piercing of the insulating medium between the primary and the secondary conductors of the transformer, and the formation of a contact between the two. Such a fault admits the high pressure into the low-pressure system, and has been the source of nearly all the troubles that have arisen. Earthing the conductor puts a great strain on this medium. Risks of fire are increased. Additional preventive measures are necessary, and hence safety devices—the best at present in the market being Major Cardew's.

The use of safety devices which earth the conductor at once when the transformer is pierced, or when high pressure enters the low-pressure system, is, in my opinion, an absolutely necessary safeguard, and I never issue any specification without requiring Cardew's device, which is thoroughly effective and reliable.

25. The use of low or of high pressure should not be a question of opinion or of objection. The supposed waste, danger, and difficulties of the one are disappearing under the able tuition of experience; while the complicated regulation and variable distribution of the other are submitting to inventive skill. It is now a question of calculation and of finance. The only variable is the number of feeding points. The determining cause and the uncertain element is the density of lamps per acre, or per mile of street. We start with this initial difficulty—that we do not know our customers, and we have to prepare for a visionary *clientèle.*

This paper has been a little discursive. Its principal object is to direct attention to the simplicity of the two-wire parallel system of distribution, to the security of the concentric main, to the devices to promote the safety of the high-pressure system, and, above all, to the necessity for regarding the whole question from the engineering maintenance point of view rather than from that of the speculative promoter.

VISIT OF THE PHYSICAL SOCIETY OF LONDON TO CAMBRIDGE.

On Saturday, the 9th inst., the society varied its ordinary procedure by paying a visit to the ancient seat of learning situated on the banks of the Cam. Assembling at Liverpool-street Station, members and visitors, to the number of about one hundred, were conveyed in saloon carriages by the 11 o'clock express direct to their destination, the whole journey being accomplished in about 75 minutes.

Amongst those present were Dr. E. Atkinson, Prof. Ayrton and Mrs. Ayrton, Mr. Walter Bailey, Mr. Shelford Bidwell and Mrs. Bidwell, Mr. D. J. Blaikley, Mr. T. H. Blakesley and Mrs. Blakesley, Mr. J. T. Bottomley, Mr. C. V. Boys, Prof. Carey Foster, Mr. Conrad W. Cooke, Prof. FitzGerald, Dr. E. Frankland and Mrs. Frankland, Dr. W. R. Hodgkinson, Prof. O. J. Lodge, Prof. Meldola, Prof. Perry and Mrs. Perry, Prof. Rücker, Dr. Sumpner, Prof. S. P. Thompson and Mrs. Thompson, Mr. A. P. Trotter and Mrs. Trotter, and Mr. G. M. Whipple.

On arriving at the historic town the party became the guests of the Cambridge members, and proceeded to Emmanuel College, where they were received by Mr. W. N. Shaw, M.A. Various groups visited the cloisters, chapel, and gardens, and at one o'clock lunch was provided in the college hall.

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* "On the Disturbances arising from the Use of Earth for Electric Lighting Purposes," March 28, 1889.—*Journal.*

At 2.30 a meeting of the society was held in the lecture-room of the Cavendish Laboratory. The papers read were all by authors resident in Cambridge, and the abstracts given below will sufficiently indicate the variety of the subjects brought before the society.

After the meeting the visitors inspected the Cavendish Laboratory. Amongst the many interesting instruments and apparatus to be seen, specially noticeable were Prof. J. J. Thomson's 50ft. vacuum tube, glowing from end to end with a luminous discharge; Mr. Shaw's pneumatic bridge, by which the pneumatic resistance or conductivity of various-shaped orifices and channels can be compared; and the new air condensers to be used by Mr. Glazebrook as standards. The Cambridge Scientific Instrument Company had an interesting exhibit, including a dividing engine, Boys's radio-micrometer, electrically-driven tuning forks, and various recording instruments, amongst which was Galton's apparatus for registering the growth of plants. Other things which attracted attention were Glazebrook's spectrophotometer, Lord Rayleigh's coils and apparatus used in his determination of the ohm, a collection of models, medals, and instruments formerly belonging to Prof. Maxwell, the resistance standards of the British Association, together with the historic rotating coils and electro-dynamometer used in the determination of the B.A. unit.

Tea was served in the Combination-room of Trinity College, and a majority of the visitors returned to town by the eight o'clock express, greatly pleased with the day's outing. Others, however, prolonged their visit until Monday, and had opportunities of discussing important physical problems with the Cambridge members. The meeting was in every sense a great success, and will long be remembered as a red-letter day in the history of the society.

At the science meeting, held in the Cavendish Laboratory, Prof. Ayrton, F.R.S., president, in the chair, the following communications were made:

"Some Experiments on the Electric Discharge in Vacuum Tubes," by Prof. J. J. Thomson, M.A., F.R.S. The phenomena of vacuum discharges were, he said, greatly simplified when their path was wholly gaseous, the complication of the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in tubes devoid of electrodes was, however, not easy to accomplish, for the only available means of producing an E.M.F. in the discharge circuit was by electromagnetic induction. Ordinary methods of producing variable induction were valueless, and recourse was had to the oscillatory discharge of a Leyden jar, which combines the two essentials of a current whose maximum value is enormous, and whose rapidity of alternation is immensely great. The discharge circuits, which may take the shape of bulbs or of tubes bent in the form of coils, were placed in close proximity to glass tubes filled with mercury, which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary or secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing the self-induction of the primary reduces the E.M.F. induced in the secondary, whilst lengthening the secondary does not increase the E M.F. per unit length. Two or three turns in each were found to be quite sufficient, and on discharging the Leyden jar between two highly-polished knobs in the primary circuit a plain uniform band of light was seen to pass round the secondary. An exhausted bulb containing traces of oxygen was placed within a primary spiral of three turns, and on passing the jar discharge a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow, which lasted for a second or more. On heating the bulb the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electro-magnet. Another exhausted bulb, surrounded by a primary spiral, was contained in a bell jar, and when the pressure of air in the jar was about that of the atmosphere, the secondary discharge occurred in the bulb, as is ordinarily the case. On exhausting the jar, however, the luminous discharge grew fainter, and a point was reached at which no secondary discharge was visible. Further exhaustion of the jar caused the secondary discharge to appear outside the bulb. The fact of obtaining no luminous discharge either in the bulb or jar the author could only explain on two suppositions—viz., that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished until a certain point was reached, and afterwards diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the presence of the electrodes. One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would present a luminous discharge in that tube.

"Some Experiments on the Velocities of the Ions," by Mr. W. C. D. Whetham, B.A. In studying electrolysis the question as to whether there is any transference of solvent when a porous wall is absent presented itself to the author. The ordinary methods of testing for transference, such as by increase of pressure, or by overflow, not being available when there is no diaphragm, the author used different coloured solutions of the same salt, such as cobalt chloride in water and in alcohol, the former of which is red and the latter blue. By putting the solutions into a kind of U-shaped tube, any change in the position of the line of junction of the two liquids could be measured. Two aqueous solutions, in which the anion was the same, were also tried, one combination being cupric chloride and common salt, and in this case the line of demarcation traversed about 7in. in three hours. The results hitherto obtained by this method agreed fairly with those found by Kohlrausch.

"On the Resistance of some Mercury Standards," by Mr. R. T. Glazebrook, M.A., F.R.S. In 1885, M. Benoit, of Paris, supplied the author with three mercury standards, nominally representing the Paris Congress ohm, now commonly known as the legal ohm. Tests of these standards were described in a paper read before the Physical Society in 1885 by the present author. Recently he had occasion to compare two of these standards with the British Association coils. The mean of many concordant results gave the resistance of one of the mercury standards (No. 37) as 1·01106 B.A.U., whilst that of the other (No. 39) was 1·01032 B.A.U. Expressing them in legal ohms, the present resistances are (No. 37) ·99986 and (No. 39) ·99913, whilst in 1885 the values obtained were (No. 37) ·99990 and (No. 39) ·99917. This shows that within the limits of experimental error the ratios of the mercury standards to the B.A. coils have remained practically unchanged during six years. The numbers given above are based on Lord Rayleigh's determination of the specific resistance of mercury, which differs appreciably from that found by Mascart and other observers. Taking the mean of the later concordant determinations, the value of the mercury standards expressed in legal ohms become (No. 37) 1·00033 and (No. 39) ·99959. The values given by the maker were 1·00045 and ·99954 respectively, showing a very close agreement. The author also found that refilling No. 37 from the same sample of mercury produced no appreciable change in its resistance, whilst No. 39 was somewhat affected by a similar operation. Experiments on the coefficient of increase of resistance of mercury with temperature gave the value ·000872 as the mean coefficient between 0deg. and 10deg. C., a number rather less than that obtained by Kohlrausch.

"On an Apparatus for Measuring the Compressibility of Liquids," by Mr. S. Skinner, M.A. The apparatus consisted of a large spherical flask with a long narrow neck containing the liquid to be experimented upon, the lower part of which was in communication, through a stopcock and flexible tube, with an adjustable reservoir. By raising or lowering the latter the flask could be easily filled or emptied, or the quantity of liquid adjusted. The flask was enclosed in a bell jar, whose interior was in communication with a pump and barometer gauge. So sensitive was the arrangement that the compression of water produced by blowing into the jar caused the liquid to descend about one centimetre in the neck of the flask. This movement corresponded with a change of volume of about half a millionth. The coefficient of compressibility had been tested at different temperatures, and the results were not very different to those obtained by Tait and others. The influence of salts in solution in charging the compressibility had also been tested, and a great difference in this respect found between electrolytes and non-electrolytes.

"Some Measurements with the Pneumatic Bridge," by W. N. Shaw, M.A. The action of the apparatus is analogous in many respects to the Wheatstone bridge, and its object is to compare the pneumatic resistances or conductivities of various orifices, channels, tubes, etc. The proportional arms are represented by two circular holes in thin plates of mica, the third arm by an aperture provided with a sliding shutter adjustable by a screw, and the fourth might consist of any aperture or tube whose conductivity was to be determined. The several apertures are pneumatically connected by large wooden boxes. The battery takes the form of a Bunsen burner with a long chimney, whilst the galvanometer is represented by a glass tube connecting opposite chambers and containing a vane which sets itself at right angles to the tube when no air current is passing. The apparatus is remarkably sensitive to movements of the shutter, and on starting or stopping the draught after balance had been obtained, effects analogous to those produced by self-induction are observed. By its use it has been found that bevelling off one side of a hole in a thin plate increases the pneumatic conductivity of the aperture very considerably, particularly when the bevel is on the egress side. Another interesting result is that for square-ended tubes of given size, the conductivity first increases as the length is made greater, and afterwards diminishes with further increase of length. Putting a flange on the outlet end reduces the anomalous effect, whilst a bevelled mouthpiece similarly placed causes it to disappear.

In the discussion on Prof. Thomson's paper, **Prof. FitzGerald** said the beautiful experiments were likely to lead to very important results. He did not quite understand how placing a fine wire in a vacuum tube could prevent the luminous discharge, for if the wire was on the side remote from the primary, and if there was any great increase in specific inductive capacity, he would have expected the air to screen the wire.

Prof. Lodge asked for further information as to the action of the magnet in preventing the afterglow, and in some cases precipitating a luminous discharge. The experiment with the exhausted bulb within the bell jar was also difficult to understand, and he did not see why one of Prof. Thomson's two suppositions must necessarily be true.

The **President** enquired whether Prof. Thomson had tried Mr. Crookes's experiment, in which the electric pressure necessary to produce a discharge was greatly lessened by putting a phosphorescent material in the tube.

Prof. Thomson, in reply, said he had not tried the experiment, but the phosphorescence he had observed was of quite a different character to that produced in Mr. Crookes's tubes. To Prof. FitzGerald he said the action of the wire was probably a question of time, and thought the whole field was in some way thrown on the wire and thus discharged. In reply to Prof. Lodge, he had not ascertained the true nature of the effect of a magnet on the glow, but he believed the glow to be due to a combination which might be prevented or facilitated by the action of the magnet causing the density to be different in different parts of the bulb.

M. Guillaume, in discussing Mr. Skinner's paper, described the methods used by Sabine, Janim, and others in determining the compressibility of liquids, and pointed out their defects. The chief difficulty in such experiments was in finding the compressibility of the reservoir. Numbers expressing the compressibility of mercury obtained by different observers were given, the best values varying between ·0000039 and ·0000040.

On the motion of **Prof. Ayrton**, seconded by **Prof. Rucker**, a hearty vote of thanks was accorded to the authors for their valuable and interesting communications, and for the kind manner in which the society had been received and entertained by the Cambridge members. **Prof. Thomson** and **Mr. Glazebrook** acknowledged the vote.

CAMBRIDGE LIGHTING.

The following report of the Electric Lighting Sub-Committee was considered by the Council on Thursday, 14th inst. We give he report and discussion herewith.

REPORT.

The Sub-Committee of the Electric Lighting Committee beg to report that in pursuance of the enquiry which they were directed to make they have visited the works of the Newcastle and District Electric Lighting Company, Limited, and of the Corporation of Bradford. They proceeded first to Newcastle. There the distinguishing feature of the generating plant is the employment of steam turbines in place of the ordinary steam engines, the shaft of each turbine being coupled directly on that of the dynamo, and the turbine rotating at a speed of 5,000 revolutions a minute. These turbines are the invention of the Hon. C. A. Parsons, who, under a new patent, manufactures them in an improved form at Heaton, near Newcastle, where he also constructs dynamos adapted for these turbines.

The sub-committee went first to Heaton, to Mr. Parsons's works, in order to examine in detail the construction of the turbines. The steam turbine consists of a shaft with a number of circular discs fixed upon it. Each disc has holes in it near the shaft, and carries on its face two or more circular rows of small vanes; and it rotates in a closed chamber which has an inlet and an outlet in the walls near the circumference. The steam is directed against the vanes by means of two or more corresponding rows of small vanes fixed on one of the side walls of the chamber, and having passed through one chamber proceeds to the next, and so on, until it reaches the exhaust.

The steam pressures are applied so as to balance one another in every direction but that of rotation, and the bearings have therefore no other pressure than that due to the weight of the rotating parts, and the friction is very small. A shaft was shown to the sub-committee that had been in use for more than four years, and exhibited only slight indication of wear. Indeed, the friction is so small where proper lubrication is provided as to be practically a negligible quantity. The dynamo, from its very great speed of rotation, requires a relatively small amount of copper wire, and is consequently less expensive than the ordinary dynamos of the same output. The combination of a steam turbine and dynamo sufficient for an electric output of 75 Board of Trade units—that is to say, which would feed 1,250 16-c.p. lamps—occupies a space of about 12ft. by 3ft., and would cost, when erected in position in Saxon-road, £650. The combination of a steam engine and dynamo for an output of 70 units, which is specified in the tender of Messrs. Laing, Wharton, and Down, costs £1,835, and requires an area of about eight times greater than that required by the turbine dynamo.

At the station at Newcastle there are four turbine dynamos, each of 75 units capacity; three being for use at any one time and the fourth spare. These are set up in a room about 50ft. long, 26ft. wide, and 18ft. high; and this room also contains the switchboard and measuring and testing instruments; and the floor space is at present about half occupied.

The boiler plant consists of three boilers of the Lancashire type, 30ft. long and 7½ft. diameter. Each boiler has a capacity of 200 nominal h.p. Two of these supply steam for the three working turbines, whilst the third boiler is kept in reserve.

The illumination undertaken by the company was at the end of January this year equal to 8,200 10-c.p. lamps, and when the sub-committee visited the station a fourth boiler was in course of erection, and another turbine dynamo had been ordered, to provide for the installations of lights for which the company were receiving applications, one of them being for 600 lights for the offices of the North-Eastern Railway Station.

The system is the high-tension alternating system with transformers at the places of supply, and the pressure is 1,000 volts.

The mains are laid in iron pipes of 6in. or 4in. diameter according to requirement, and the company get the pipes laid by workmen usually in the employ of the gas and water companies. To prevent injurious friction in drawing the mains into the pipes French chalk is used; and the pipes are kept free from water by a current of air, partially desiccated, forced through them by a fan at the generating station.

The sub-committee made enquiries as to the cost of the installation and its maintenance; and by the courtesy of Mr. Parsons, who is managing director of the company, and of Mr. Patterson, the secretary, they were allowed to see a copy of the return made to the Board of Trade showing the capital and revenue accounts of the company up to the 31st of December, 1890, and the returns made for the last five months to the directors showing the monthly output and cost of working. Copies of some of these documents accompany this report.

From the capital account it appears that the following sums have been expended on plant, that is to say:

	£	s.	d.
On building and machinery	7,681	1	9
,, pipes and mains (including cost of laying)	5,578	2	1
,, transformers and meters	3,926	1	11
,, electrical instruments	101	3	2
Making a total of	£17,286	8	11

The buildings are rented by the company, and the amount expended in adapting them to the purposes of the company was £600, which sum is included in the item of £7,681. 1s. 9d.

The revenue account covers the period of six months ending 31st December, 1890. From this it appears that the company received:

	£	s.	d.
By sale of current per meter at 6d. per B.T.U	1,848	11	7
,, public lighting	67	13	0
,, rental of meters	116	3	5
Making a total of	£2,032	8	0

And they have expended (among other sums) the following:

	£	s.	d.
For coal, including all costs of carriage, etc.	428	17	8
,, oil, waste, and engine-room stores	108	11	11
,, wages at generating station	208	0	0
,, other salaries	148	8	2
,, rents, rates, and taxes	177	11	6
,, attending and repairs to public lamps	11	8	5
,, directors' fees and other management expenses	105	10	6
Making a total cost for the generation and distribution of the current and the management expenses of	1,188	8	2
Deducting this amount from	2,032	8	0
There is a balance, gross profit for the half-year, of	£843	19	10

The total quantity of electricity generated during the six months was 104,881 Board of Trade units. Of these 81,677 units were sold, and 2,360 used in the works; whilst 20,844 units were not accounted for, that is to say, were expended in the transformers and circuits.

The sub-committee made enquiry more especially as to the expenditure on coal and labour. It seems that the coal consumed for each unit sold was about 23·4lb., and cost 1·133d. This large consumption is due to the fact that the turbines in use at the Newcastle station are of the old type and require a larger expenditure of steam per horse-power than other engines; and this tells in an especial degree during the hours when the load on the machines is light. In the improved form which the sub-committee saw at Mr. Parsons's works at Heaton the turbines are steam-jacketed, and the admission of steam is made intermittent at less than full load. These two changes are said to effect a large saving of steam. And when, in addition, the machines are worked with a condenser there will be a saving, according to the estimate of Mr. Parsons, of 35 per cent. at least. If this should prove to be the case, as the sub-committee believe to be likely, the consumption of steam per horse-power in a turbine will be about the same as in a Willans engine of the same power at full load, and probably much less at light load.

The amount of labour employed at the works is remarkably small. There are two shifts, consisting of one stoker in the boiler-house, and one engineer in the turbine-dynamo room, during the day; and one stoker, one engineer, and one electrical superintendent during the night. The turbines and dynamos require so little attention during the hours of light-load that there is little else to be done than record in the diary the half-hourly readings of the various instruments.

No collector is employed by the company, but an allowance of 5 per cent. is made to those consumers who pay their bills on or before a given day—a system which, the secretary states, works satisfactorily.

It ought to be added that the company have no special plant for arc lighting. The arc lamps are supplied from the mains, a suitable transformer being set up in some convenient place near.

So far as the sub-committee could learn the supply of current gives satisfaction to the consumers, and there has been no hitch in the working since the commencement of supply, except once for a short time when water fell on the switchboard and a short circuit was established.

From Newcastle the sub-committee proceeded to Bradford. They were met at the station by Mr. Alderman Morley, to whose courtesy and attention they are much indebted. He showed them some very fine examples of shop lighting by electricity, and then accompanied them over the generating station. This station has extensive office and store accommodation, and a large room for accumulators; but the engine and dynamo room is of about the same size as the one at Newcastle, whilst the boiler-house is smaller.

The engines are of the Willans type, coupled direct to the dynamos, which latter give off current at low tension, about 115 volts. There is a large battery of accumulators, which supplies the current during the hours of light loads.

The sub-committee were shown a copy of the expenditure account on buildings and plant, from which it appears that the following (among other sums) were expended—that is to say:

	£	s.	d.
On buildings	4,685	0	0
,, engines, dynamos, etc.	13,600	0	0
,, batteries	1,076	4	6
,, boilers (Lancashire type)	2,605	0	0
,, meters	730	0	0
,, overhead traveller	205	0	0
,, trenching for laying mains.	2,200	0	0
There were other items which with the foregoing made a total of	£27,500	0	0

Three engines and dynamos were provided by the above expenditure, each having an output of 75 Board of Trade units. A fourth engine and dynamo have recently been erected having an output of 150 units.

From the revenue account it appears that in the six months ending 31st December, 1890, £1,499. 12s. 6d. was received by the sale of electricity and £34. 14s. 9d. by meter hire. The total revenue for the half-year was £1,552. 9s. 9d.

The price charged was raised from 5d. to 6d. in the course of the half-year. The sub-committee could not learn how many units were generated or how many sold; but they estimate the quantity sold at 65,000 units.

The revenue charges were for the half-year:

	£	s.	d.
By salaries and wages	410	17	10
,, rates and taxes	104	6	6
,, coal	247	5	3
,, miscellaneous	238	12	3
,, rent of land	83	18	1
,, interest to bank	89	11	0
	£1,174	10	11

The cost of coal per unit sold was ·923d. The price of the coal used at the Bradford works is less than that used at the Newcastle works.

At the request of the sub-committee Mr. Parsons has furnished an estimate (which accompanies this report) of the cost at which he is prepared to supply and equip a complete electric light generating station on the lines of that of the Newcastle and District Electric Lighting Company, but differing from it in two points—namely:

(1) That two of the plants are arranged for and fitted with condensers and independent air and circulating pumps; and

(2) That the voltage is 2,000, instead of 1,000 as at Newcastle.

The total estimate amounts to £8,731. 10s., and includes the following items set out with details:

	£	s.	d.
For four turbine alternators, each capable of an output of 75 units, and two of them condensing, including condensing plant	3,660	0	0
,, three Lancashire boilers	2,740	0	0
,, main steam and exhaust pipes and water pipes chiefly of copper	1,300	0	0
,, overhead traveller	170	0	0
,, fresh water heating tank	235	0	0
,, switchboard and instruments	376	10	0
,, contingencies	250	0	0
Total	£8,731	10	0

Mr. Parsons has also furnished a ground plan of a proposed generating station, from which Mr. Fawcett, who accompanied the sub-committee, has made a design of the buildings, and he estimates the cost roughly at £3,000. If an additional sum of £1,768. 10s. be allowed for extras, including fencing, making an artesian well for a complete supply of water for all purposes, and earthenware pipes for the outflow of the condensing water to the river, there will be a total capital outlay of £13,500 for building and equipping a generating station complete.

This station would be capable of maintaining 3,750 16-c.p. lamps lighted at one time, with one 75-unit plant in reserve, as against the 2,400 similar lamps and 60 arcs provided in the estimate of Messrs. Laing, Wharton, and Down.

	£	s.	d.
Adding to the above sum of	13,500	0	0
For mains, including cost of laying	8,000	0	0
For transformers and meters	4,000	0	0
For purchase of land	1,050	0	0
There would be a total expenditure of	£26,550	0	0

By this expenditure an annual sum of £6,562 could be earned, adopting the basis of calculation employed by Dr. Fleming in his report on tenders.

The members of the sub-committee, so far as they are able to judge, are of opinion that the system tendered for by Mr. Parsons should be adopted, subject to there being no fundamental objection on the part of any expert who may be consulted by the Corporation.

I. That the report of the Electric Lighting Sub-Committee, dated April 20, 1891, and which has already been printed and circulated, be adopted by the Council.

II. That in the event of the above report being carried, Prof. William Garnett, of the Durham College of Science, of Newcastle-upon-Tyne, be appointed to act as consulting electrical engineer, in carrying out the scheme for lighting the borough with electricity submitted by Mr. Parsons.

DISCUSSION.

Councillor Morley proposed the adoption of the report. He stated that the system recommended by the committee might seem to some to be rather new, but he would remind them that it had proved a success at Newcastle, and the Government had installed it at Scotland Yard.

Councillor Scott mentioned that the committee had had considerable difficulty in coming to a decision upon the subject. They had to deal with a very abstract and complicated subject. Experts were called to their assistance, but they seemed to have been strong advocates of their own particular views. The committee had decided, upon much conflicting evidence, to recommend the Council to adopt Mr. Parsons's system. The recommendations in favour of that system were, the machinery was cheaper and lighter than those required in connection with other systems laid before them, and less outlay would be required on buildings. The objection to it was, as Mr. Morley had pointed out, it was rather extravagant in the way of coal; but the great advantage was that it required less original outlay.

Councillor Dr. Porter thought there was not sufficient information before the Council to enable them to come to a decision upon that question. He considered that the Council would be most foolish to form an opinion unless it had full information as to the tenders that came before the committee. He moved, as an amendment, "That the consideration of the report of the Electric Lighting Committee, dated April 6th, 1891, be postponed till a full report on the tenders for the electric light and buildings connected therewith, received in response to the invitation of the Corporation; the report of Dr. Fleming on the report of the committee; the report of any expert who may have been consulted by the committee in accordance with the resolution of the Council passed at their last meeting, together with all documents or correspondence of a public character bearing on the question had been communicated to and considered by the Corporation."

The **Mayor** mentioned that Dr. Fleming's criticisms were fully replied to by Mr. Parsons.

Councillor Dr. Porter said he thought Dr. Fleming had not been properly treated by the Corporation.

Councillor Hill seconded the amendment, and said he thought the matter was being carried on without sufficient knowledge on the part of the members of the Corporation. He did not wish to say one word against the electric light—he was as anxious as anyone to have it—but he felt that, considering the amount of business they had to go through that morning, it ought not to be rushed through.

Councillor Vinter, referring to the question of contracts, said it was customary when a committee had matters of detail of that kind they should recommend what, in their judgment, they considered best. He was aware that the practice of the Council recently had been always to upset the judgment of the committee. The efficiency of Mr. Parsons's scheme was being demonstrated at Newcastle and Scotland Yard. The committee were perfectly satisfied in recommending the scheme, and were prepared to stand or fall by it that day.

Councillor Bell supported the amendment.

Alderman Kett also thought the matter should be referred back to the committee.

Councillor Flack asked whether Mr. Morley would agree to that course.

Councillor Campkin further suggested that the question should be discussed by the Council at a meeting called specially for the purpose.

The amendment of Dr. Porter was agreed to.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for last week were £5,176.

City and South London Railway.—The receipts for last week were £665, against £695 for the week ending May 9, and £733 for the previous week.

West India and Panama Telegraph Company.—The receipts for the half-month ended May 15 were £3,116, as against £3,270. The January receipts, estimated at £6,397, realised £6,583.

Western Brazilian Telegraph Company.—The receipts for last week, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,170.

COMPANIES' MEETINGS.

WEST COAST OF AMERICA TELEGRAPH COMPANY.

The fourteenth ordinary general meeting of this Company was held on Friday last at Winchester House, Mr. Alfred Marshall presiding.

In proposing the adoption of the report and accounts, the **Chairman** said the report gave the shareholders a clear insight into the business done by the Company during the year, and although it had not yielded as handsome a return as 1889, the result was to be considered satisfactory. The gross earnings of the Company, which, although nearly the same as those of 1888, fell short of those of 1889 by about £20,000. That was to be accounted for by the repairing steamer earning about £5,400 less than in the previous year, owing to their neighbours having built and used their own steamer instead of employing the Company's as heretofore, and also by there having been less messages between Europe and the east coast of South America, because there had been no repetition in 1890 of the interruption which occurred on the Eastern line during 1889, and which gave this Company such exceptionally large traffics in that year. The shareholders would observe an increase of about £1,000 in the interest account, which was due to the larger investments of the reserve fund.

The motion was carried unanimously, and a dividend at the rate of 1 per cent. declared, making 2½ per cent. for the year.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.

The sixth annual meeting of this Company was held on Friday last, at Bristol, under the presidency of Mr. Charles Nash. The report of the Directors (*vide E.E.* for last week) was taken as read.

The **Chairman**, in moving the adoption of the report, dealt with the question of capital expenditure, which in 1890 was £24,415, or £2,402 less than in 1889, but while the expenditure was less the rate of increase of the gross revenue was much larger. The advance in net revenue was still more striking, being the largest increase of any year in the history of the Company. The increase was £3,240, which was about 35 per cent. on the previous year's net revenue. Then, again, the working expenses were over £400 less than the annual increase since 1885. With regard to their plant, not only had it been well kept up, but, as stated in the report, the substitution of the more durable and efficient copper bronze wire had been extended. Many improvements had been made at various centres designed to give the subscribers the latest and best possible service. The balance, after paying interest on debenture and dividend on preference shares, would admit of a small dividend on the ordinary shares; but the Directors, after full consideration, had decided to advise carrying forward the balance of £2,677, after placing an additional £500 to the credit of the reserve fund, which would then amount to £2,200. The Chairman then spoke of several points in the report bearing on the increase in the number of subscribers, the increase in the wire mileage, and the increase of trunk messages, and contended that those facts pointed conclusively to the steady and continuous progress of the Company. Having alluded at length to their trunk system and its working, he said he hoped they would agree with him that the considerable outlay of £46,883 on trunk lines had been fully justified by the results. He found that between Cardiff, Newport, and Swansea there were in April 13,384 calls, and as each call was answered, the total communications were 26,768, or more than 1,000 a day for the 26 working days of the month in that district alone. During the past year their trunk system had been extended, *via* Gloucester and Worcester, to Birmingham and the Midlands and the North of England. In the local exchanges he found that there was an increase of more than half a million calls in 1890 over 1889, and as each call was answered, more than six million communications were made. Not only was the business continuous, but it was going on more rapidly than ever; and considering the near expiration of patents, and the rumour of competition, this fact was a striking proof of the firm hold that the telephone had on the public mind. Eighteen weeks of the current year had passed, and in that time they had an increase of £1,845, against £1,504 in the corresponding period of last year, which showed a large weekly increase. Such continued and increasing advance was most satisfactory. There was another point, and that he thought was a very important one. The greater part of their agreements were for long periods, and had a considerable unexpired time to run. From a carefully prepared table, he found that at the end of last November they had 1,104 agreements for the year, and 2,141 for periods ranging from one to nine years. These unexpired periods of agreements represented on November 30 last a contract rental to the amount of between £86,000 and £87,000, constituting an element of great stability to the Company. These agreements had been secured by charging lower rates for the longer periods. They would agree with him that in case of a purchase by the Post Office or the National Company these long unexpired agreements, and the great general elasticity of their business would constitute important elements of value. It only remained for him to state that one of their patents expired last December, and that the other would run out on July 31. This would relieve them from the payment of a considerable amount of royalty, and without committing themselves then to any precise figures, he might say that it was their intention to reduce the rates payable by their subscribers to at least the amount of the remission of the royalty, and they hoped that the reduction would lead to a considerable increase of business. This reduction would probably take effect from August 1.

Mr. Mark Whitwill seconded the adoption of the report, remarking that the figures quoted that day proved conclusively that what they said years ago was true, that business people would gradually begin to appreciate the advantages of the telephone.

In reply to a question why the Directors had not thought it right to declare a dividend on ordinary shares,

The **Chairman** said the Directors did propose a dividend of ½ per cent., but on consulting the members of the Board in London they took a different view, and declined to sanction the dividend being made; therefore they had no choice but to give way, as the voting power of the Directors in London was so large.

The report was then adopted.

Upon the proposition of the **Chairman**, a dividend at the rate of 6 per cent. upon the preference capital was declared, and the amount already paid by the Directors on account of such dividend was approved.

The sum of £500 was, on the proposition of the **Chairman**, ordered to be placed to the reserve fund for depreciation of plant, etc.

Mr. Inskip proposed the re-election of Mr. Charles Nash as director, and **Mr. Whitwill**, who seconded it, mentioned that the Chairman gave the greatest attention and thought to the Company's business. The re-election, which was supported by **Mr. Pole**, was unanimously agreed to.

Mr. R. Cory (South Wales) was also re-elected director, and the auditors, Messrs. Hudson Smith, Briggs, and Co., were reappointed.

Mr. Reed thought the time had arrived, now that the Company was progressing so satisfactorily, when the Directors' remuneration should be increased, and he would move that it be increased from £500 to £700 per annum.

Mr. Inskip said he should be glad to second anything in the way of remunerating the Directors properly for their trouble; but he thought he had sufficient knowledge of the matter to say that the Directors would prefer to have the sum limited to £600.

Mr. Reed altered his resolution to £600, and this was adopted.

The **Chairman** acknowledged the resolution, but added that, while the Directors were attentive to the Company's interests, much of the success of the undertaking was due to Mr. Lewis, their general manager.

COMPANIES' REPORTS.

CONSOLIDATED TELEPHONE COMPANY.

The report of the Directors of the Consolidated Telephone Construction and Maintenance Company, Limited, for the year ending March 31, 1891, states that the accounts show a net profit of £11,573. 8s. 9d., which, with the amount carried forward from last year, leaves a balance of £13,416. 6s. 8d. for disposal, after making provision for doubtful debts. The Directors propose to deal with this amount as follows—viz., to pay a further dividend of £7 per cent. for the half-year on the ordinary shares, and £6 per cent. on the preference shares, making, with the interim dividend paid in November last, £6 per cent. for the year on both descriptions of shares; writing off the sum of £530. 3s. for depreciation of plant, machinery and furniture, £63. 16s. 8d. from cost of new building, and the sum of £436 from goodwill and patent rights, thus leaving a balance of £1,716. 4s. 10d. to carry forward. The lawsuit in Belgium, relating to the patents in which the Edison Gower-Bell Telephone Company is interested, is still in the hands of the solicitors, but it is hoped that a decision will soon be arrived at. One of the patents for telephones held by the National Telephone Company expired on December 9th last. This has had the effect of enabling the Consolidated Company to sell telephones to the public; and, so far as the Board can judge, an increasing business is in prospect. The shareholders may rely upon every effort being made to keep the Company's manufactures well in advance of both home and foreign competition. The subsidiary companies continue to make most satisfactory progress. The Telephone Company of Austria had, in 1890, 2,868 subscribers and a rental of £18,100, and in 1891 3,263 subscribers and a rental of £20,500. The Anglo-Portuguese Telephone Company had, in 1890, 1,915 subscribers and a rental of £12,232; in 1891, 2,074 subscribers and a rental of £13,458. The total increase for the year was, therefore, 554 subscribers and £3,626 of rental. In accordance with the articles of association, the following Directors retire by rotation, and, being eligible, offer themselves for re-election—viz., Sir Alexander Armstrong, K.C.B., etc., and Arthur Henry Baker, Esq.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	1⅞
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9½
London Electric Supply	5	2½
Swan United	3½	4¾
St. James'	—	6¼
National Telephone	5	4½
Electric Construction	10	7¼
Westminster Electric	—	4

NOTES.

Sofia.—The time for the reception of tenders for lighting Sofia expires on July 13th.

Vienna.—There are 28 miles of mains belonging to the International Electrical Company in Vienna.

Stafford.—Dr. Bostock Hill has been speaking out well in his lecture at Stafford for the advantages of electric lighting.

Hornsby's.—Messrs. Richard Hornsby and Sons, Limited, have declared a dividend of 3s. 3d. per ordinary share, and 6 per cent. on preference stock.

Melbourne.—The New Australian Electric Light Company of Melbourne are adding four more engines and dynamos, making the plant capable of supplying 28,000 lamps.

Whitby.—A petition, praying to be heard against the provisional order for Whitby, has been deposited in the private Bill Office of the House of Lords by Sir Chas. W. Strickland, Bart.

"Drehstrom."—The term rotary current—in German "Drehstrom"—has become quite a catchword in Frankfort. Songs are sung over cups of lager beer extolling the beauties of the great discovery.

Ruston-Proctor's.—Messrs. Ruston, Proctor, and Co., Limited, after writing off £12,000, have declared a dividend of 5s. a share, making with the interim dividend 7½ per cent. per annum.

British Association.—A special meeting of the Nottingham Town Council have determined to invite the British Association to meet in that town next year, a proposal it is thought will be accepted.

Electric Diagrams.—Mr. Francis B. Crocker has just published in the New York *Electrical Engineer* a set of conventional electrical diagrams used to indicate the various parts or connections in electrical work.

Birmingham.—Among the Bills for provisional orders which have been found to comply with Standing Orders, is one giving power to the Birmingham Electric Light Company over many of the principal streets.

Indiarubber.—A winding-up order has been made against the Indiarubber Estates Company, registered last year for the working of a concession in Liberia. Non-payment of calls is alleged as the cause of failure.

Scarborough.—In the House of Commons on Tuesday the Electric Lighting Provisional Orders (No. 5) Bill, which provides for the lighting of Scarborough by means of electricity, was read a second time and committed.

Electric Haulage.—At the close of last year the Compagnie Continentale Edison installed an electric haulage plant at the Mines des Marles. This has proved so successful that a large extension is now going to be made.

Venice.—There are to be great festivities at Venice on the occasion of the launch of the "Sicilia." The programme will include a Venetian regatta, illumination by electricity of the basin of St. Mark, coloured lamps, fireworks, and a festival ball.

Quick Telegraphy to America.—The result of the Derby was delivered to New York by the Associated Press at 3.20½ p.m. (London time), having been received at the London agency at 3.20 p.m. The time occupied in transmission was thus only half a minute.

Mining Engineers.—A general meeting of the Federated Institution of Mining Engineers is being held Thursday and to-day at the rooms of the Civil Engineers. Papers are read, and an exhibition including mining lamps and electrical apparatus used in mining is held.

Ader Telephones.—In the Scotch Courts the case of United Telephone Company and Andrew Muirhead, of Glasgow, with reference to the supply of Ader telephones has resulted in the defendant offering to pay £5 damages and expenses, and this was accepted. He also consented to interdict.

Notting Hill Station.—The report of the Notting Hill Electric Lighting Company will be found in another column. The directors of the company have determined to hold their adjourned fourth general meeting at their central electric light station, Bulmer-place, Notting Hill, on Saturday, on the occasion of the opening of the station.

A Successful Electric Railway.—The electric railway of Monchsberg, near Salzburg, says *Electricité*, has carried 66,712 tourists and 1,000 tons of merchandise during the last year. The profits have risen to 417,111 florins, and the company have decided to pay a dividend of 7 per cent., and to extend the station at Salzburg.

Accumulator Cars.—Mr. Graff Baker writes, on behalf of the Thomson-Houston Company, to state with reference to a note last week, that the Thomson-Houston system is exclusively employed upon the West End railway system, Boston, U.S., and that there is not, to their knowledge, a single accumulator car of any kind in that city.

Derby Illuminations.—During the visit of the Queen to Derby the illuminations were enhanced by the electrical arrangements, which were under the direction of Mr. Langdon, electrician to the Midland Railway Company. Elaborate devices of "V. R.," and crowns and mottoes, were successfully carried out, and created great interest in the district.

Patten Alternate-Current Motor.—Lieut. Patten describes in the New York *Electrical Engineer* two types of alternate-current motors he has recently put to successful tests. The motor has a revolving commutator which, as the speed increases, tends to rectify the current more and more till at last, at the normal speed, it is fed by a direct pulsating current.

Extension.—We are notified by Messrs. W. H. Wilcox and Co. that they have taken the adjoining premises in Southwark-street to their present address as engineers' stores for electric light companies. This extension will enable them to hold a larger and more varied stock of engineers' tools, oils, and other materials constantly in use in central stations.

Leeds Telephones.—The scheme recently projected for the opening of telephone exchanges throughout the West Riding of Yorkshire has been followed by amalgamation, by which the Leeds Telephone Exchange passes into the hands of the Mutual Telephone Company, with a view to the extension of their metallic circuit system to the principal towns of Yorkshire.

City Lighting.—A circular issued by the City of London Electric Lighting (Pioneer) Company, Limited, states that suitable sites have been secured by the contractors for the central generating stations, and that good progress has been made with the necessary buildings, machinery, and mains. It is hoped that the first portion of the public lighting in Queen Victoria-street will be completed by June 1st.

Frankfort.—The work for the installation of the 300-h.p. transmission from Lauffen to the exhibition is being rapidly pushed forward. The 1,000 oil insulators required are already supplied, and the turbine at Lauffen is being erected. The work of manufacture of the electrical apparatus by the Allgemeine Company is being pressed forward, and it is expected that the whole will be ready well within the time stipulated.

Barnet.—On enquiry being made at the Barnet Local Board whether any tenders had been sent in in answer to the advertisement, the clerk said a few enquiries had been made—by the Gulcher Company, and Messrs. Cowdy and Co., the latter for oil lamps. No other letter was received from any other electric company. The Board are also having negotiations with the gas company, and were to leave the matter for a month to see what tenders were received.

Hutin - Leblanc Motors.—The alternate - current motor of MM. Hutin and Leblanc, mentioned in our last issue, has, we believe, been very favourably reported upon by one of our best-known electrical experts in England. Its principle is the slight changing of phase to obtain the rotary field by means of a condenser. The only question is the durability of the condenser under constant action. We shall be interested to hear of one of these motors put to actual work over some time.

Provisional Orders.—The examiner in the House of Commons, on Monday, found compliance with Standing Orders in the case of various provisional orders relating to the electric lighting of Edinburgh, Paisley, Preston, Liverpool, Toxteth Park, Birmingham, Cardiff, Scarborough, Torquay, Tunbridge Wells, Withington, Exeter, Ipswich, Newport (Mon.), Poole, Hertford, Bromley, Kingston-on-Thames, Weybridge, Camberwell, Islington, Southwark, Westminster, Wandsworth, Clerkenwell, Chelsea, and Woolwich.

Australian Alternate-Current Motor.—Mr. Arthur J. Arnot, lately with Mr. Ferranti, and brother to Mr. Wm. Arnot of the London County Council laboratory, has patented an alternate-current motor which works well and starts under load. If he has not "solved the question," he has at least carried out a step in the right direction of alternate-current transmission. Mr. Arnot is getting on wonderfully well in Australia, and has quite an influential position, having just been appointed engineer to the Corporation of Melbourne.

Barnsley.—The Barnsley Town Council on Thursday last week again considered the electric light question. The Park and Lighting Committee recommended that the consideration of the present scheme be adjourned; and that the borough surveyor be directed to prepare a scheme and plan for the supply of electricity to a smaller area, and to submit the same to the consideration of the committee as early as practicable. A full report will be found in another column. The result was that the recommendation was carried, and a fresh scheme will therefore be drawn up at once.

What went ye out for to see?—Little birds have whispered that the report of the Lighting Committee of Cambridge, given and commented upon in our last issue, is the result of the true guide, philosopher, and friend being absent. The committee set forth to view one installation where Robey's engines and Mordey's alternators rule supreme, and found themselves at another installation where Robey and Mordey were not, but Parsons was. The committee saw and reported, but they have not yet seen the installation they set out for to see. A queer, very queer proceeding, my masters.

Bristol Central Station.—The designs of Mr. W. H. Preece and Mr. Gisbert Kapp for the central electric station for the Bristol Corporation, have been submitted to the Electric Light Committee and approved. The detailed plans and specifications will now be proceeded with. The plans for the buildings are already in hand, but some difficulty is experienced on account of the land being "made ground," which will have to be piled for foundations. The first part of the plant will be for 10,000 lamps, a total of 40,000 when complete being provided for. The total horse-power in the finished station will be 4,800 h.p.

Underground Railway for Berlin.—A scheme for an underground railway in Berlin has been submitted for approval by the directors of the Poetsch mine and foundry engineering works at Magdeburg. The railway, for which no fixed scheme has yet been determined upon, will be propelled either by electromagnetic force, by atmospheric pressure, or by hydraulic pressure. The undertaker of the work intends to sink the 60 entrance shafts which are required by a method he has himself devised. The promoter of the plan has also applied for permission to erect the necessary buildings above ground, as well as for the concession to construct an underground railway.

Central London Railway Bill.—The time having expired for lodging petitions in the House of Lords in opposition to the Central London Railway Bill, it is found that 10 petitions have been deposited. The petitions now deposited do not indicate any serious opposition to the preamble of the Bill. Four petitions are from owners of property who did not appear in the House of Commons, whilst the remaining six are from petitioners who lodged petitions in the House of Commons, but who, with the exception of the London County Council and Mr. Maurice Powell, a landowner, did not appear to support their petitions. The Commissioners of Sewers for the City of London, who opposed this scheme in the House ot Commons, have now presented a petition against any alteration being made in the Bill.

Newcastle.—At the meeting of the Newcastle Town Council on Wednesday, the Town Improvement Committee presented a petition, which they recommended to be sealed and sent to Parliament, against the Bill to confirm the Newcastle and District Electric Lighting Company's provisional order. Mr. Sanderson moved that the petition be sealed. Sir Benjamin Brown said there would not be the slightest difficulty with the company in coming to an agreement with the Corporation; the fight was really one between the Corporation and the Board of Trade. Alderman Richardson understood that the Board of Trade wished to entrench upon what the Corporation believed to be its rights. Alderman Hamond said there was never a more righteous petition. It was unanimously decided that the petition be sealed.

Electric Welding.—The Thomson Electric Welding Company are building electric welding machines of large size for welding rails, for the Johnson Company, of Johnstown, Pennsylvania. The New York *Engineering News* states that the latter company has been conducting extensive experiments in rail welding, and is said to contemplate an expenditure of about 250,000dols. for plant, etc. The largest machine will have a base 14ft. by 18ft. and weigh about 20 tons. A large dynamo-room of brick is being built, and each dynamo will be driven by its own engine. An alternating current will be led from each of the dynamos to the particular welding machine it is to serve, although the current will be so arranged in the dynamo-room, by means of a switchboard, that it can be either distributed, concentrated, or used direct, as occasion may require.

Tramway Schemes.—Entirely new lines of tramways are the desideratum of electrical engineers for their schemes. Given a fresh start, a fair field and no favour, they can, they think, show better results than present systems. Present tramway companies are full of rolling-stock, they have little fresh capital to spend, and new lines ought therefore conceivably be the best field for electric work. It certainly cannot be said that England has enough of tramways everywhere—subsidiary railways as feeders to the great lines. Lancashire is not an unlikely field for such work, and we notice in our contemporary the *Contract Journal* an advertisement from a civil engineer, who is desirous of meeting with firms to develop two important tramway schemes. Electricity is not mentioned, but for new and important lines, if they are going to be designed, electric traction might certainly be considered.

Incandescent Lamps in France.—Mr. S. Flood Page writes in the *Times* of May 21: "In the account which appeared in your issue of Tuesday, the 19th inst., of the incandescent electric lamp factory which Mr. Hoster has founded near Dieppe, the following words occur: 'It is believed that this establishment for the manufacture of incandescent lamps is the first established in France upon a commercial basis.' I beg leave to inform you that our friends and allies, La Compagnie Générale des Lampes Incandescentes, which company holds the Edison and Swan lamp patents for France, and most of the countries on the Continent, are manufacturing at Ivry, near Paris, thousands of lamps weekly, for which they find a ready sale in France and in other continental countries. Their factory is capable of turning out an almost unlimited number of lamps, and has been working ever since its establishment on a commercial basis, and paying dividends with regularity."

City Lighting.—Letters were read from the Brush Electrical Engineering Company and the Laing, Wharton, and Down Construction Syndicate at the last meeting of the Commissioners of Sewers, with copies of communications addressed to the Board of Trade relative to the transfer of the undertakings in regard to the City electric lighting to a new company about to be formed, and applying for the Commissioners' approval thereof. A letter was also read from the Board of Trade on the same subject. On the motion of Mr. Sayer, seconded by Mr. Johnson, these letters were referred to the Streets Committee. Mr. Pannell explained that the electric lighting Acts provided that the Board of Trade and the local authority might approve of a transfer to another contracting party, therefore these applications were primarily made to the Board of Trade with an endeavour to prove the advisability of a company being formed to take over their contracts, and the Board of Trade simply asked the Commissioners for their views on the subject.

Electric Cranes.—We have receive an advance copy of a new catalogue of the electric cranes of Messrs. R. Bolton and Co., of 110, Leadenhall-street, E.C., which is, as far as we are aware, the first of its kind dealing entirely with this application of electric motors. It is carefully got up, and, besides illustrating the various familiar types of cranes electrically operated, it specifies sizes and dimensions and prices thereof. Some interesting information as to the superior economy of electric cranes is also given, with a concise statement of their general advantages. Altogether the book is one which should be examined by all engineers, and will be of special interest to electrical engineers as evidence of the wide scope for the use of distributed electricity in industrial operations. There is, further, a description of Mr. Reginald Bolton's electrical ship's winch, which appears to present considerable advantages over the clumsy and noisy steam winch, and which, now that the use of electricity on board ship is widely increasing, should find a ready application.

New Uses for Lithanode.—We learn that Profs. Perry and Meldola are about to investigate and to report upon the applicability of Mr. FitzGerald's lithanode as the anode in the decomposition of chloride for the production of bleaching compounds. It is well known that, so far, science has rendered available for use as anodes in the electrolytic production of chlorine only three substances—viz., gas-carbon, platinum, and the highly conductive solid form of peroxide of lead known as lithanode. Since the disintegration of carbon employed for this purpose is only a question of months, if not of weeks, and since the normal price of platinum, to say nothing of its present inflated value, is almost, if not quite, prohibitive to the use of this conductor, the question as to the applicability of the third substance mentioned becomes one of considerable practical interest. In conjunction with a considerable number of authorities, we are inclined to think that some electrolytic process of chlorine generation will constitute the basis of the bleaching industry in the future.

Electric Light for Transporting Plants.—By the aid of the electric light the Botanical Mission despatched some months since by the authorities of Kew to the West Indies were extricated from an embarrassing dilemma. They had with them a number of Wardian cases containing vine cuttings and Gambier plants, which it was deemed very desirable to introduce into the islands; but, unfortunately, cold weather set in, and the efforts to convey these tender plants, which had so often ended in failure, threatened once more to result in disappointment. The difficulty was that if kept on deck they would be inevitably destroyed by the low temperature; while if taken below, the absence of light, which is so necessary to the existence of the delicate Gambier plants, was almost certain to be equally fatal. Under these circumstances it occurred to Mr. Morris to avail himself of the electric light, of which there was an abundance aboard the "Atrato." The experiment, says the *Daily News*, proved in every way successful. Mr. Morris expresses the opinion that the use of the electric light for the safe passage of valuable plants during the winter months is capable of being greatly extended.

City Subways.—At the meeting of the City Commissioners of Sewers on Tuesday, Mr. Wood moved "That it be referred to the Streets Committee to consider and report as to the desirability of constructing subways under the principal thoroughfares of the City for the reception of the gas, water, electric, and other mains, and also to furnish an estimate of the probable cost of the same." In giving some reasons why the ratepayers should be spared the inconvenience and annoyance they now laboured under, Mr. Wood stated that by a calculation he had discovered that the streets of the City had been opened no fewer than 3,613 times, in order that underground wires and mains might be examined. Speaking in favour of the construction of subways, he called the attention of the Commissioners to the success which had attended the construction of one mile 332 yards of subways in the City, where telephone, telegraph, or electric wires, or gas and water mains could be examined freely and without annoyance to anyone. At least, he said, he asked the Commissioners to refer to the Streets Committee his motion, with an instruction to the committee to report. Mr. Malthouse seconded the motion, which was carried without further comment.

"Engineering Magazine."—The first two numbers of the new departure in scientific journalism lie upon our table, sent to us from America. Imagine opening a *Scribner's* or *Harper's* and finding to your great interest (if you are a science student or engineer) that all the articles are upon technical or engineering subjects, treated in a descriptive, popular, and scientific manner by well-known and able writers, and all, or nearly all, illustrated in that artistic, delicate style which we are accustomed to in that class of magazine. The title on the first number was *Engineering*, but has been changed—and wisely—to *The Engineering Magazine*. There are articles upon "Ancient and Modern Water Wheels," "Danger Signals about the Boiler," "The Rapid Transit Problem"; Mr. Herbert Laws Webb has a prospective article on "A Chat with Europe by Telephone"; Mr. Frank Sprague discourses on "The Splendid Record of the Electric Railway." A feature seems to be made of a technical *causerie*, entitled "Engine-room Chat," and reviews of the month are given on civil engineering, architecture, electricity, mining, and mechanics. The price is 1s. monthly, and it is published by *The Engineering Magazine* Company, World-building, New York.

Proposed Subways in Sheffield.—At a meeting of the Highway Committee on Friday, the report of a subcommittee appointed to consider the question of constructing subways in the centre of the town was submitted, and plans and sections of the suggested scheme were also presented by the borough surveyor. The suggested subways are to be from below Change-alley, along High-street and Fargate, to Cheney-row, and from The Pack Horse Hotel, Snighill, along Westbar to Corporation-street. The objects are to provide improved sewers, accommodation for gas and water mains, electric light and telephone wires, pneumatic tubes, etc., and to make side chambers to the respective properties along the routes for the conveyance of house drainage, the private gas and water services, and telephone communication. It is proposed further, if found desirable, to construct vaults under the footpaths for the convenience of the different occupiers of properties, these vaults to be let at a rental. It was mentioned that this system of subways had been for several years extensively adopted in Nottingham, and applied to many of the new thoroughfares in London with most satisfactory results, one great advantage being that it saves the surface from being constantly disturbed. The sub-committee's report was adopted.

Lightning in the London-Paris Telephone.—A most extraordinary accident occurred on Tuesday, according to a Reuter's telegram, at the London-Paris Telephone office in the Palais de la Bourse. One of the employés, a gentleman named Weller, wished to communicate with the London office on a matter of service. He had already rung up the English officials, and the bell having sounded in reply, took up the receivers and put them to his ears, when he suddenly sustained a shock of electricity of such severity that it threw him staggering backwards against the door of the telephone cabinet, which, not having been properly fastened, flew open, with the result that he was thrown heavily to the ground. He was injured on the forehead and across his right eye; but whether the bruises were due to the fall or were caused by the instrument is not certain. M. Weller suffered from the shock, but was soon able to resume his duty. It appears from enquiries that similar accidents, although less serious, have occurred at this telephone office on several previous occasions. The officials attribute them to lightning striking the wire either at San Gatte, where the submarine cable ends, or at the terminus of the land wire on the Place de la Bourse. Such accidents, it is declared, can easily be prevented by the simple expedient of erecting lightning conductors at the point where the cable comes ashore and at the terminus in Paris.

Electrolytic Production of Chlorate of Potash.—The works at Vallorbes is now producing, the *Bulletin International* says, one ton a day of chlorate of potash by the electrolytic process of Gall-de-Montlaur. The output is one kilogramme (2·2lb.) per horse-power every day of 24 hours. The process consists in electrolysing a solution of 25 per cent. of chloride of potassium at the temperature of 45deg. to 55deg. C. Chlorine and potassium are set free, which again react upon the chloride not decomposed, and transform it into chlorate of potash. When the electrolysis is complete, the chlorate is precipitated by successive crystallisations. The manufacture presents several practical difficulties; it is indispensable, among other things, that no metallic particle whatever should come into contact with the baths, on account of the formation of chlorides and oxides, whose presence render the purification difficult, if not impossible. The present works comprise 270 vats, of which half are in actual use. This corresponds to an output of 50,000 litres of solution a day. The anodes are of iron, separated from cathodes of platinum by a porous diaphragm. The temperature of the bath is maintained constant by the passage of the current. The motive force, obtained from the fall of the River Orbe of 2,500 h.p., is transmitted by means of six turbines of 150 h.p. driving six Thury dynamos of 150 kilowatts. It is estimated that 100 cubic metres of hydrogen are given off at the cathode for every ton of chlorate precipitated: this gas, in escaping into the atmosphere, takes with it chloride of potassium, which is deposited all round the works.

Ship Lighting.—The troopship "Tamar" has suffered in two ways by the absence and abuse of the electric light. It suffered an accident in the Suez Canal, and the heat in the tropics was intensified by the antique system of lighting by means of oil lamps and candles still in force. The collision in the canal is alleged to have been caused by mismanagement on board the s.s. "Harrow," of London, which was using her electric light and had successfully passed two other vessels before colliding with the troopship, which was lashed up for the night. She struck the "Tamar" on the port quarter, carrying away chains, accommodation ladder, and boats' davits. The crash of the collision caused some apprehension, but the damage inflicted to the "Tamar" was not serious. Prior to this incident, a steamer in charge of the same pilot who was so unfortunate on board the "Harrow," ran aground and blocked the canal for nearly a whole day. Men-of-war do not take those electric lights which merchant vessels hire for a few pounds, when desirous of passing through the canal at night, but if necessary they make use of their own search-lights. The result is said to result in the Government ships taking much longer in passing through. Much dissatisfaction was expressed by the "Tamar's" passengers that so efficient a troopship should be improperly lighted. A considerable sum was expended in preparing the ship to receive the electric light some time ago, but the work has never been completed. The "Himalaya," which is a slower and less commodious vessel, has already been supplied with electricity. In other respects the passengers, both fore and aft, were very comfortable, and appear to have had a pleasant voyage

Electric Cranes at Southampton.—The General Works Committee of the Southampton Town Council reported at their last meeting that the draft form of agreement with the Southampton Electric Light and Power Company for the supply of electric energy for cranes, for lifting purposes, was submitted, the arrangement being for a term of seven years, the Board guaranteeing a minimum payment of £200. The sheriff moved the adoption of the report, saying that they had protected the interests of the Board without in any way unduly pressing the company, who were bound to supply them with sufficient power. Mr. Emanuel remarked that by the agreement the Board were bound to pay £200 a year to the company for seven years, whether they acquired the power required or not, whilst there was no provision binding the company to recompense the Board if the supply of electricity failed. The sheriff said that a clause had been inserted in the agreement providing that if the company failed to furnish an efficient supply they should pay so much per diem to the Board. This was discussed, and after looking at the Board of Trade "consent" to the company, the Harbour Board's solicitor advised that the clause was unnecessary, because, under the company's license, supposing they failed in their supply, they would have to pay to the Board £2 per day. Mr. Emanuel said he was not satisfied. The company did not compel any private consumer to bind himself in such a manner for seven years, and, therefore, he did not see why the Board should be so bound. He moved, as the subject was not one in which they need hurry, that the matter be referred back till the next Board meeting. The amendment was eventually accepted, and it was ordered that a copy of the agreement should be forwarded to each member of the Board.

Killarney.—Among the Bills which have complied with Standing Orders, was one to confirm the provisional order made by the Board of Trade under the Electric Lighting Acts, relating to Killarney. The undertaker is described as Charles Edward Leahy, of Ballycarty, Tralee. The area of supply is the urban sanitary district of Killarney. The order contains provisions to the following effect: That the undertaker shall lay down mains in certain specified streets within a period of two years, and it provides that the remainder of the area shall be lighted on certain specified conditions for the deposit of a certain sum as security for the execution of works. For the audit account of the undertaking, for the approval by the Board of Trade of the system upon which energy is to be supplied, and the issue by them of regulations for securing the safety of the public, and for ensuring a proper and sufficient supply of energy. For the execution of the necessary works and the breaking up of streets and the alteration of pipes under streets, for regulating the manner in which energy is to be charged for, and fixing the maximum price to be charged. For the appointment, remuneration, and duties of electric inspectors, and the testing of electric lines and other works, and for holding enquiries by the Board of Trade as to the causes of accidents affecting the public safety. For the supply, use, and certifying inspection of meters. For the revocation of the order under certain circumstances. In addition to the above provisions, the order contains a provision for the purchase by the local authority of the undertaking within six months after the expiration of a period of 28 years from the commencement of the order and within six months after the expiration of any subsequent period of seven years.

A Technical Review of Reviews.—We noticed a few months ago the proposed issue of a monthly international technical review. The first monthly part is now issued, under the title "Pantobiblion," making a well got up magazine-like periodical of 287 pages. It is edited by A. Kersha, civil engineer, Fontanka 64, St. Petersburg, and is evidently the result of a great deal of work and trouble. In the first place, it is written in we hardly like to say how many languages—seven or eight at least—Russian, English, French, German, Dutch, Spanish, Norwegian, etc., and others are promised if circumstances require it. It contains notices of the books of the month on technical subjects, with a wide range of matter—mathematics, physics, botany, mineralogy, mechanics, electricity, mining, railways, building, military and marine arts, agriculture, and so forth—each with the titles, place of publication, and other information. Next, we find short reviews on the more important books, each in the language of the book itself; thus we have reviews on Hospitalier, Salomons, F. B. Bladt, and others in electrical science. After this we have some 130 pages containing the headings of all the articles in the principal journals in the beforementioned departments—a digest that must naturally be of great service to scientists who wish to keep abreast of the latest practice or theory. This technical review of reviews has the disadvantage or advantage (just as it may be regarded), of being polyglot—English engineers would probably prefer to have such a work all in their own tongue, but such a consummation, though devoutly to be wished, is yet distant in technical circles. The languages are all competently treated so far as we are able to gauge in those known to us—English, French, and German. There are exceedingly few errors; these are only too likely to arise in such an undertaking. The only ones we notice are that "English" is spelt "english" (regarded a grave error, as belittling the country, by some folk), though the same is done with "french" and "german"; also "Periodicals' Contents" is written instead of "Contents of Periodicals"—not very serious errors. The reviews or notices seem particularly straightforward, judicious, and idiomatic. "Pantobiblion" will be issued monthly (London, Swan Sonnenschein and Co), and the price is 24s. yearly, post free.

Cost of Electric Street Mains.—The following note on the cost of mains is given in the *Abstracts* of papers in foreign transactions published by the Institution of Civil Engineers, abstracted from a paper by Dr. Gustav Rasch in the *Electrotechnische Zeitschrift*, 1890, page 658: "The author bases his calculation on the formula: cost of cable $= a\mathrm{V} + b\mathrm{L}$, in which a and b are constants depending upon the price of copper, and the price and quality of the insulating material, whilst V represents the volume of the cable, and L its length. By means of this formula he obtains approximate estimates for the various arrangements of feeders and mains which may be adopted in any given case of distribution, the mains being calculated for an equal maximum drop in pressure, and the feeders for equal energy loss. Comparing first the three-wire with the two-wire system, he finds that the total volume of copper in the former is 60 per cent. of the latter, whilst the length is 150 per cent. This refers to the mains, whilst in the feeders the volume is 27·6 per cent. of an equivalent two-wire feeder and the length 150 per cent., there being three wires instead of two. The differential current in the middle wire is assumed not to exceed 10 per cent. of the total current. For the four-wire system the author finds the following figures of comparison with an equivalent two-wire system. Mains: volume, 46·6 per cent.; length, 200 per cent. Feeders: volume, 16 per cent.; length, 200 per cent. Similarly for the five-wire system. Mains: volume, 40 per cent.; length, 250 per cent. Feeders: volume, 9·4 per cent.; length, 250 per cent. A practical example is given to explain the application of these figures. The author assumes that the feeders and mains for a certain area of distribution have been formed on the two-wire system. The question to be solved is how far can the total cost be reduced by adopting a multiple-wire system. The figures for the two-wire system are:

Volume of mains, 1,500,000 cubic centimetres; length, 5,000 metres.
,, feeders, 1,600,000 ,, ,, ,, 10,000 metres.

The cost of the various systems is then found to be as follows:

System.	Two.	Three.	Four.	Five wires.
Cost in £	5,775	3,695	3,685	3,935

In conclusion, the author points out that his method does not pretend to be more than a rough approximation to be used in working out preliminary estimates."

THE ROYAL NAVAL EXHIBITION.

To the seafaring men, and the jolly tars of Old England—the officers, midshipmen, crews of our Navy and merchant service, and their business and family connections—the Royal Naval Exhibition at Chelsea must prove a very Mecca. They will all go and visit the long galleries of relics and of pictures and models, the old ship "Victory," the Eddystone Lighthouse, the North Sea trawlers, the model of the turret of a modern man-of-war with its 110-ton gun, and will view with pride, mingled with a feeling of enthusiasm, the evolutions of the bluejackets on gun and cutlass parade, and the display of miniature torpedo practice on the artificial lake. The exhibition is not an engineers' exhibition, and must not be judged from this standpoint, though there are not a few interesting exhibits, some really magnificent specimens of forging, gunnery, and naval architecture, and one of the best arranged and most compact electric light central stations—by Messrs. Siemens Bros.—that has been on view during late years.

THE LIGHTHOUSE.

The exhibition is near Sloane-square Station, whence penny buses run direct to the entrance. In the grounds the most noticeable object is, of course, the model of the Eddystone Lighthouse, designed by J. J. Webster, M.I.C.E., and built by D. Charteris, of Westminster. The model is a full-size representation of the new Eddystone Lighthouse, as designed by Sir James Douglas, F.R.S., every stone being accurately copied. Its height is 170ft. to the top of the lantern roof. The outside covering of the structure is of cement upon a steel lathing, known as "expanded metal lathing"—a material lately introduced by Mr. J. F. Golding, and made by the British Metal Expansion Company, of West Hartlepool. The lighthouse is illuminated at night by what is supposed to be the most powerful electric light in the world—similar to that at St. Catherine's, Isle of Wight, which is given as 5,000,000 c.p., but if anything, we believe still stronger. The lamp is supplied by Messrs. Chance Bros. and Co., Limited, of Birmingham, and is a double group-flashing dioptric light, revolving in periods of 30 seconds, the two flashes being separated by an interval of four seconds, and the groups by an interval of 21 seconds, the whole revolution occupying three minutes. The fluted carbons, as introduced by Sir James Douglas, are 65 mm. (2½in.) in diameter. The light in the original lighthouse is by means of oil.

In the further question of lighthouse illumination there are shown Sir William Thomson's apparatus for giving distinctive characteristics to fixed lights by means of eclipse—"long-short, short-long, long-short-short," etc.—shown by means of incandescent lamps. Messrs. Chance Bros. and Co. have also occulting white lights for harbour use, and Messrs. John Trotter and Co., of Great Winchester-street, have automatic revolving beacon lights for harbour use. Messrs. Siemens Bros. and Co. exhibit a Holophote of the Admiralty pattern, electrically controlled and worked from a distance.

ELECTRIC CENTRAL STATION.

The electric light installation for lighting the galleries and the arc lights in the grounds has been supplied, as we have said, by Messrs. Siemens Bros. and Co., Limited, Woolwich, together with Messrs. Willans and Robinson, Thames Ditton. It is a compact, neat, pleasant installation in the form of a model central station, and is well worthy the visit of electrical engineers and public officers interested in public supply. The immense dynamos work smoothly, silently, and sparklessly, and the whole room has the air of good arrangement and workmanship.

The building, which adjoins the Albert-embankment, is divided into two parts—viz., engine and dynamo room, and boiler-house. The engine and dynamo room measures 68ft. by 29ft., part of which is railed off and devoted to visitors. The part railed off for machinery measures 48ft. by 21ft., and within this small space are placed engines and dynamos collectively of over 1,100 h.p. The engines, as well as the steam and exhaust pipes, and the large ventilating fan driven by a separate engine, are supplied by Messrs. Willans and Robinson, Limited, and the dynamos by Messrs. Siemens Brothers and Co., the combined plant being coupled together and erected in place by Messrs. Willans and Robinson. The dynamos, except in one case, are carried upon bed-plates, which form an extension of the engine frame. The cables connecting the dynamos with the switchboard, and the switchboard itself, which is placed on the west side of the engine-room, are supplied and fixed by Messrs. Siemens Bros. and Co. The engines are divided into two groups. The group at the south end occupies a space of 28ft. by 21ft., and includes three large direct-driving compound engines, indicating 300 h.p. each. With the exception of a similar engine, also with a Siemens dynamo, which has been running for the past year in the electric light station of the Corporation of Bradford, these engines are said to be the largest direct-coupled high-speed engines in existence. These three engines and dynamos (with six of the boilers in the boiler-house) in themselves represent the plant of a central lighting station of some magnitude, capable, if worked together, of supplying current for 8,000 or 9,000 lights of 16 c.p. each. The engines are of the kind known as Willans patent central valve engines ("I.I.I. size"). They are single acting, and run at 350 revolutions per minute. All the brasses and bearings are in constant thrust, and the wearing surfaces are either immersed, or are continually bathed in oil. The entire absence of belts is certainly a striking feature of the Royal Naval engine-room, and its result in saving of space, as well as in freedom from noise, will attract the notice of the visitor accustomed to the electric light departments of former exhibitions. The present installation, in fact, constitutes the first public exhibition of direct-driving plant upon a large scale, although similar (but smaller) engines have been supplied for central lighting stations in England to the extent of 20,000 h.p.

The larger dynamos are of Messrs. Siemens's "H.B." pattern, each capable of supplying 1,500 amperes at 120 volts (180 kilowatts) when driven at 350 revolutions. They have several times been run up to 1,700 amperes. Two of these are in constant use, and the third is for reserve. The commercial efficiency of these dynamos is given at 94 per cent. at full load. The combined efficiency of engine and dynamo as one machine is about 86 per cent. of the indicated horse-power at full load. The consumption of steam per hour (the engines being here non-condensing and working at 120lb. pressure) is a little over 20lb., corresponding with a consumption of 23¼lb. per electrical horse-power hour. Similar engines, but condensing and working with steam at 160lb. pressure, require 14lb. of steam per indicated horse-power hour, or, reckoning the same "combined efficiency," a little over 16¼lb. per electrical horse-power.

Another group is formed of three engines and dynamos of a smaller size. One of these is the combination of Willans engines with Siemens H.B. dynamos, of which large numbers have been supplied to her Majesty's ships. The output of the largest size used in the Navy is 400 amperes and 80 volts, at 400 revolutions per minute; but the dynamo shown is rather larger and runs rather faster, giving 120 volts, the latter voltage being more useful for the exhibition.

Another set represents the single-acting open engines supplied to the Navy under recent specifications, the dynamo being of the ordinary Siemens pattern. The remaining engine—central valve pattern "G.G." size—drives an alternating Siemens dynamo giving 40 kilowatts for supplying 500 amperes of current to the large arc light in the Eddystone Lighthouse.

On one wall is shown a central station engine room switchboard with all necessary controlling switches, cut-outs, meters, and measuring instruments, together with transformers for 50,000 watts. All are of the best and careful workmanship, and the whole station makes a very pretty appearance.

The boiler-house alongside measures 60ft. by 29ft., and contains 10 steel locomotive boilers, of the well-known make of Messrs. Davey, Paxman, and Co. These supply steam to the electric light engines, and also to the other machinery in motion. These boilers contain more than

7,000 square feet of heating surface, and are capable of evaporating over 30,000lb. of water per hour; they are self-contained, made for a working pressure of 140lb. per square inch, and tested to 250lb. per square inch. A steel steam receiver runs the entire length of the boilers, connected to each by a separate stop-valve, so that either or any of the boilers can be immediately shut off, if necessary The object of the receiver is to give dry steam to the engines, and to turn back to the boilers any condensed steam.

The pumps for feeding the boilers are provided by Mr. A. G. Mumford, of Colchester, and the injectors are of Messrs. Gresham and Craven's manufacture.

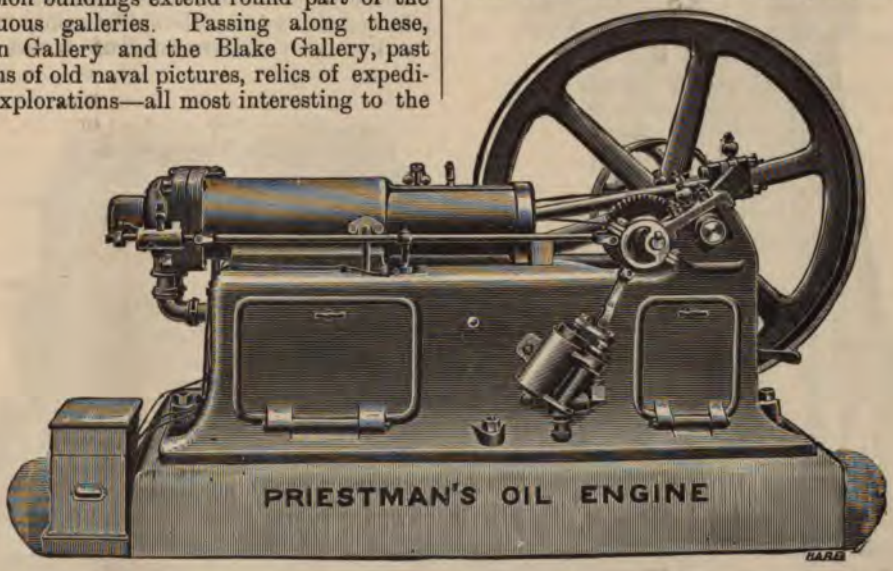
The distribution of the current from the terminals of the machines, including the wiring and actual lighting of the entire exhibition, is in the hands of Messrs. Siemens Bros. and Co., Limited. The feeding mains and most of the distributing mains are of Siemens's lead-cased and iron-sheathed type, laid underground.

The lighting of the exhibition building is carried out by about 2,000 incandescent lamps of 16 c.p. The public lighting is effected by means of nearly 200 arc lamps, Siemens's new pattern, taking nine amperes each. These are mostly carried on 40ft. lattice iron masts in groups of six.

In various parts of the exhibition it is intended to show motors worked by electrical energy.

GENERAL EXHIBITS.

The main exhibition buildings extend round part of the grounds in continuous galleries. Passing along these, through the Nelson Gallery and the Blake Gallery, past wonderful collections of old naval pictures, relics of expeditions, battles, and explorations—all most interesting to the naval mind and to the public—we come across, occasionally, exhibits especially appealing to the electrical engineer. Up the steps leading to the Cook Gallery, Messrs. Wm. Harvie and Co., 222, Broomielaw, Glasgow, show a neat ship-lighting plant of a Harvie dynamo coupled to a Chandler high-speed engine, exhibited in conjunction by Messrs. Bumsted and Co. Near here is the ingenious model, often mentioned in Royal Society reports, showing the action of trade winds on the tidal streams, and particularly the Gulf Stream, incidentally illustrating the reason of England's beautifully warm climate, so abundantly shown during these latter days! To pass this, however, we notice a stand showing the various types of fluted carbons used by Sir James Douglas, ranging from the ¼in. specimens first used to the immense carbons now needed in lighthouses. Messrs. Elliott Bros. have a fine exhibit of naval appliances. The electric ship-signalling apparatus, which we have before described, is there seen, with their engine revolution indicator, a model showing the new Granville electric ship's log, and many specimens of fine instruments. Perhaps the most interesting is a set of Lieut. Fiske's electric range finders for heavy guns. By means of these instruments, placed one in the bow and the other in the stern of the ship, the officer in charge of the guns at any other part of the ship can ascertain by simply looking at any indicator the distance of a target, fort, or ship upon which to point his guns. Two observers, who are in communication with each other by a telephone attached to the telescope of the instrument, sight any determined object through their telescopes, and as soon as both are on the object an electric bell rings at the indicator to notify that the indication of the distance can be taken.



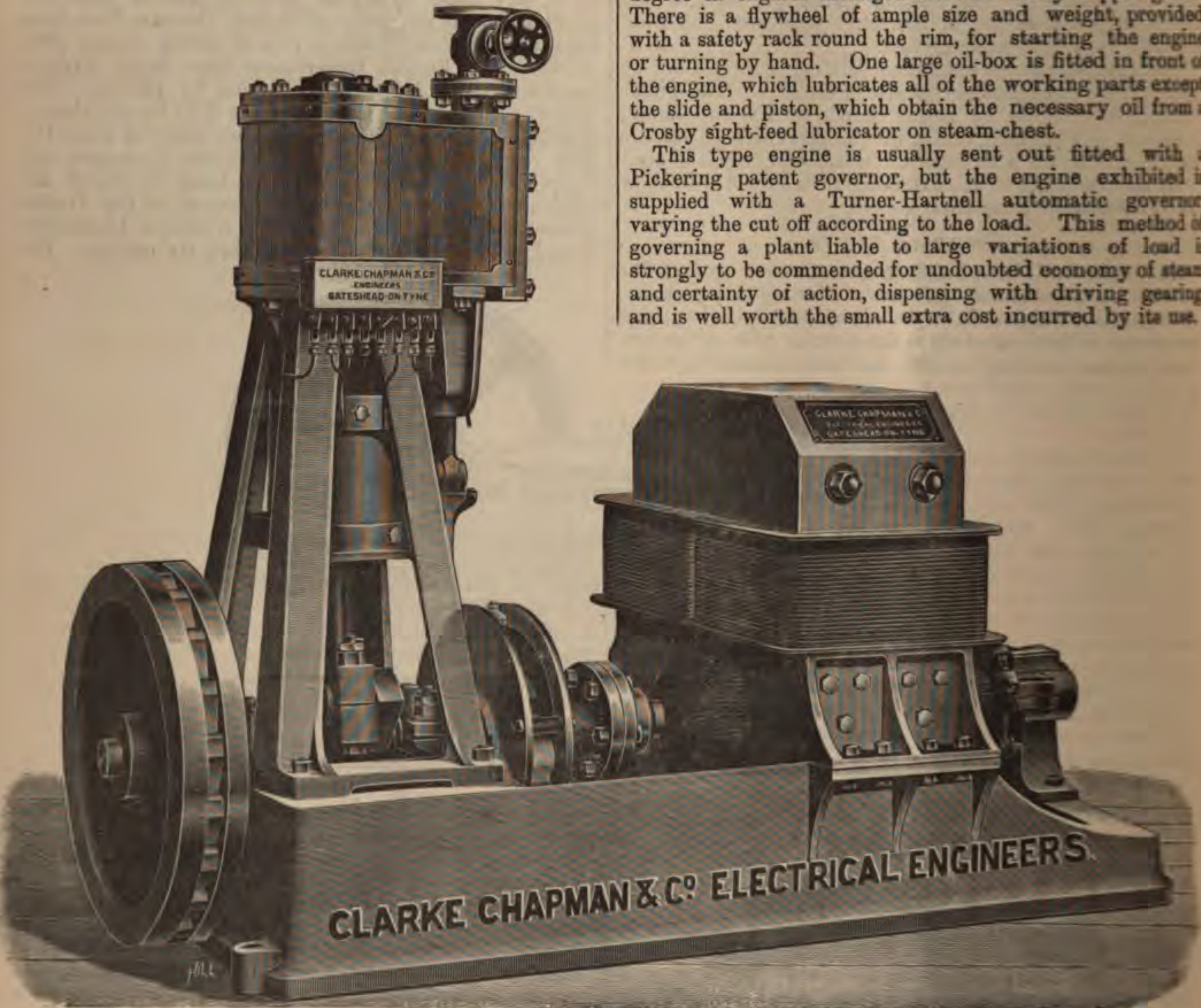
Most of the electrical and mechanical exhibits are grouped together in a separate gallery in the grounds, known as the Camperdown Gallery, and in the verandah running along outside this. A fine specimen of the Priestman oil engine is shown running, 5 h.p., using ordinary paraffin oil.

About two years have now elapsed since the Priestman oil engine was put upon the market, and we think it may interest our readers to know that considerable progress has already been made in the supply of these engines. Orders amounting to £45,000 are stated to have already been received for engines varying in size from 1 h.p. to 25 h.p. for a very large variety of purposes, and to meet the growing demand the works of Messrs. Priestman Bros. have been largely extended with a view to giving prompt deliveries. The English Government have lately given a repetition order for a 3-h.p. engine for printing; the Victorian Government have taken one of 25 h.p. for electric lighting, and orders have lately been received from the New South Wales, Spanish, New Zealand, Norwegian, and Egyptian Governments. The Priestman oil engine has been also adopted by the Elder Brethren of the Trinity House, the Irish Lights, and the Northern Lighthouse Board, the latter having already taken six engines. The fact that these engines have been adopted by these three public bodies in Great Britain and Ireland responsible for the saving of life at sea, is certainly a very exceptional proof as to its real value. A large number of engines have lately been supplied for electric lighting, pumping, farm purposes, dairy plant, and printing, besides others for collieries and mines. Many repetition orders are stated to have been received, and Messrs. Bell Bros., Limited, have recently taken three 5-h.p. engines, after using one of a smaller size for about 14 months. Three first prizes have been awarded these engines in three successive years by the Royal Agricultural Society—a token of merit, it is thought, unprecedented in the annals of this society. After many years of experimental work, Messrs. Priestman announce themselves in a position to build a really reliable motor, one making the user entirely independent of boiler, gas works, or driver, and offering advantages which probably no other similar motor can offer with an economy of fuel stated by Prof. Unwin as "almost unprecedented." Electrical engineers who have contracts in hand for country residence lighting will like to see this engine at work.

Along the Camperdown Verandah, Mr. Kerbey Bowen, electric launch builder, of Ray Mead Works, Maidenhead, has a very pretty and serviceable electric pinnace. The following are the details: Length 20ft., beam 5ft., draught 1ft. 6in.; speed 6 knots, length of run with one charge, 6 hours; specially designed motor of slow speed, 400 revolutions per minute, 80 per cent. efficiency; also specially constructed switch for running ahead or astern.

The Fowler-Waring Cable Company show insulated wires and cables for all classes of electrical work; lead-covered mains for central station distribution, and armoured cables for torpedo work, besides various telephone cables, joints, and distributing boxes.

The carbons of Messrs. Lacombe and Co. have their place properly here, showing lighthouse carbons and arc light carbons as used in the Royal Navy; low-voltage carbons, fluted carbons, and also carbon brushes for dynamos and motors. Messrs. Boult Bros. and Co., 38, King William-street, have an interesting stand of lubricators—their speciality, "valvoline," as used in the electric light department of this exhibition—together with sight-feed lubricators.



Messrs. Woodhouse and Rawson have a stand crammed with their celebrated products. Amongst their exhibits we notice a model of Bolton's electric winch, an extremely useful application of motors. Ventilating fans are of course shown, and an electric launch motor, shown revolving with wide metal blades at 2,000 revolutions a minute, should, we think, have some protection from access of the public's fingers. Jensen bells and signalling lanterns are shown, and the engineering department of Woodhouse and Rawson is represented by a pair of compound launch engines. They also show the new type Epstein accumulators. Their marine fittings are quite in their place in this exhibition.

Messrs. Crossley Bros. have, as usual, one of their world-famed Otto gas engines.

In the Camperdown Gallery, Messrs. Clarke, Chapman, and Co. have arranged a very neat and effective-looking stall at this exhibition. The chief feature of their exhibit, of which we give an illustration, is an engine and dynamo combined, for ship lighting purposes. The plant, which is compactly arranged, consists of an engine and dynamo coupled direct and bolted on the same bedplate, the engine having a cylinder 8½in. diameter with an 8in. stroke, being of sufficient power to drive a dynamo giving an output of 9,000 watts.

The chief points in favour of the engine are its extreme simplicity and easy accessibility of all working parts, both of which points are invaluable where the space available for electric light plant is as limited as it is on board ship. The makers state that they have special appliances for machining the frames and cylinders of these engines, whereby the main bearings, motion bar seatings, motion bars, cylinder, and cylinder stuffing-boxes are all bored at one setting, the cylinder flanges being also faced at the same time, thus ensuring all these surfaces being perfectly true with one another, a result unattainable to the same degree in engines arranged with ordinary slipper guide. There is a flywheel of ample size and weight, provided with a safety rack round the rim, for starting the engine or turning by hand. One large oil-box is fitted in front of the engine, which lubricates all of the working parts except the slide and piston, which obtain the necessary oil from a Crosby sight-feed lubricator on steam-chest.

This type engine is usually sent out fitted with a Pickering patent governor, but the engine exhibited is supplied with a Turner-Hartnell automatic governor, varying the cut off according to the load. This method of governing a plant liable to large variations of load is strongly to be commended for undoubted economy of steam and certainty of action, dispensing with driving gearing, and is well worth the small extra cost incurred by its use.

The dynamo, which is of the well-known drum type, is constructed to give an output of 9,000 watts, or to furnish 150 16-c.p. lamps at 65 volts. The commutator is made of hard drawn copper bars insulated with mica, the brushes being made specially adjustable.

Amongst their exhibits, Messrs. Clarke, Chapman, and Co. have two large search-light projectors, one being made to Admiralty requirements, and one of the type used by ships during their passage through the Suez Canal. The Admiralty one is constructed to give a light of 30,000 c.p., and is especially designed for flashing and signalling purposes. The Suez Canal projector, on the other hand, is designed for 15,000 c.p., and requires about 50 or 60 amperes at 65 volts. Both these projectors form good examples of neat mechanical design and workmanship combined with high electrical efficiency. We understand Messrs. Clarke, Chapman, and Co. will have at the exhibition, in a few days, one of their turbo-electric generators, which will form a novel feature at the exhibition.

The India Rubber and Gutta Percha Company, of Silvertown, have a case of beautiful samples of their cables for light, line, and torpedo work. Mr. L. Bristol, 138, Loughborough-park, shows his portable electric safety lamps and batteries.

The General Electric Power and Traction Company have a large stand which attracts much attention. They show the Immisch dynamo combined with direct-driving engine, as used for lighting on board ship. They have a specimen of their tramcar gearing, motor, and frame as used on their storage cars. Electric tools being as yet a distinct novelty, the electric metal drill in action is the centre of much interest, and the switches, fittings, fans, etc., give samples of other departments. The new carbon brushes thickly electroplated with copper, now used on their motors, are very serviceable improvements. Outside the gallery, in the grounds, this company have a full-sized electric launch, showing the batteries and the arrangement of motors and gearing. The great field for these vessels in naval circles should, we fancy, bring in many enquiries and orders for this class of work.

Messrs. Drake and Gorham have their latest improved type of storage cells, made with strips of lead formed on the Planté principle. The Planet Engineering Company exhibit their Planet arc lamp and a marine automatic search-light taking up to 100 amperes, the carbons fed, as in the smaller lamps, by means of an electric motor.

An interesting piece of apparatus is a chronograph shown in working order, and used to indicate "personal error," by recording the interval of time which elapses between the receipt of an intimation to the train by way of the eye and the actual carrying out of an action, such as firing a gun or pressing an electric contact. This is lent by the Lords of the Admiralty, who exhibit many other electrical and torpedo instruments.

Messrs. W. H. Allen and Co. have a combined electromotor and fan for use on board ship for ventilation or forced draught, capable of delivering air at 12,000ft. per minute. They have also a very fine dynamo for ship lighting, of the capacity of 400 amperes at 80 volts, at 320 revolutions with 100lb. of steam, using 33·7lb. of steam per electrical horse-power hour, as used on H.M. ships. Also a smaller dynamo for the same purpose, giving 130 amperes at 62 volts, for 250 revolutions, the weight of combined engine and dynamo being 50cwt., and taking very little space.

The Marine and General Automatic Company, 6, Great St. Helens, have an electric "audible indicator" for ship steering. Messrs. Engelbert and Co. show their oils.

In the centre of the gallery is an immense tank built by Messrs. Siebe, Gorman, and Co., submarine drivers and engineers, in which the use of electric lights under water is exemplified in action.

A number of applications of electricity to ship use are shown by Mr. C. E. Kelway, of 71, Shardeloes-road, New Cross—electric shell fuses fired by the conductivity of salt water, an electric log and range finder, marine engine governor, and other appliances. Messrs. Davis and Timmis show electric screws of all kinds.

An important exhibit is that of Messrs. Belliss and Co., Ledsam-street Works, Birmingham, in conjunction with Messrs. Latimer Clark, Muirhead, and Co., of Westminster. The combined firms exhibit one of three sets of dynamo machinery to be fitted to H.M.S. "Crescent." The engines are of Messrs. Belliss's patent single-valve open type, with ball governor, and they drive a direct-current self-regulating Westminster dynamo supplied by Messrs. Latimer Clark, Muirhead, and Co., capable of sustaining a current of 400 amperes, with an energy of 80 volts at the machine terminals when the engines are run at about 320 revolutions per minute.

They have also one set of dynamo machinery of the same power as above, but consisting of a new Admiralty pattern dynamo made by Messrs. Siemens Bros. and Co., and driven by an open engine with valve gear worked off the connecting rods, similar to the machinery supplied for the electric lighting of H.M.S. "Royal Oak."

Messrs. Clark, Muirhead, and Co. also show their Westminster dynamo commercial patterns; output 320 revolutions, 80 volts, 400 amperes. Besides this they also show Farquharson and Lane's patent electrical speed indicators, specially designed for use on board ship, for indicating the number of revolutions per minute at which an engine is running, and Commander Lloyd's patent ship's telegraphs for use on board ship for communicating from bridge to engine-room and helmsman. Beams of light from search-light projectors of the Admiralty pattern, supplied by Messrs. Clark, Muirhead, and Co., are thrown over the grounds at various points after dusk.

The work shown by Mr. Ronald A. Scott, of Acton Hill, is amongst the most important in this exhibition. Mr. Scott makes a special point of ship lighting for the Admiralty, and seems to have achieved success from the notice he exhibits that on May 13 the contract for this year's supply of projectors has been placed in his hands. He exhibits dynamos, motors, and search-light projectors, and his special type of exchange switches.

The search-light on the top of the grand stand is also supplied by Mr. Scott. This light has an intensity of 27,000 c.p., and the peculiarity of the beam of light thrown, its perfect parallelism and pure whiteness of character, is obtained by the use of Scott's patent mirror. The mirror used for this lamp is 24in. in diameter.

It may be mentioned that outside the building of the Ordnance Section a time gun is exhibited, made to fire automatically by electricity. The hours at which it is fired are 3 p.m. and 7 p.m., and great accuracy is obtained by the combination of clockwork and electric arrangements.

THE ELECTRIC TRAMWAY AT BUDAPEST.*

BY F. UPPENBORN.

The use of overhead conductors for tramway purposes, introduces in many plants almost insuperable difficulties. In many large towns especially it will be not possible to obtain the permission for this kind of working, and the choice will therefore mostly have to be made between accumulators and underground conductors. Traction by means of accumulators has many points preferable over the other arrangement. Independence of a central station, which was formerly considered as a chief consideration, has gradually lost its importance in the course of successful endeavours to raise the safety of central station working on the one hand, and the security of the connection of the electric car to the central station on the other. The most important advantage arises from the fact that accumulator cars can at once use the existing tramway lines. Against this advantage there are, however, many considerable disadvantages, amongst which we may point merely to a striking one—namely, the absence of an accumulator thoroughly suitable for tramway purposes and tested by lengthy work. This reason was at the time of choice of the system for the electric tramway at Budapest even more preponderating than it is at present, when we are, at any rate, in possession of satisfactory accumulators for stationary purposes. The decision was therefore made for underground conductors.

The electric tramway as it has been carried out and is already working in three streets of Budapest is a slotted conduit system, and in exterior appearance hardly differs at all from ordinary tramways. As shown in Fig. 1, the rails, corresponding in some degree to the rails of the Haarmann system, are separated by a gap of 33 mm. (1·3in.). One rail of the track is screwed by means of wrought-iron angular fishplates on 18 cm. (7·1in.) wide cast-iron frames corresponding to the profile of the conduit running beneath this rail, and designed to receive the conductors. The conduit has an oval, egg-shaped profile, 28 cm. (11in.) wide and 33 cm. (13in.) high; at its upper side it has a 33 mm. (1·3in.) wide gap corresponding to that of the rail, so that, as in other conduit systems, the slot in the rail leaves the conduit open at the top along its whole length. The iron frames, on which the double rail is screwed, occur at intervals of 1·2 m. (4ft.). Besides supporting and fastening the rail, they serve also as skeleton to the conduit, and, further, they carry the insulators supporting the electric conductors. The conduit, the whole of which runs at a constant depth of 57 cm.

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* Translated from *Elektrotech*

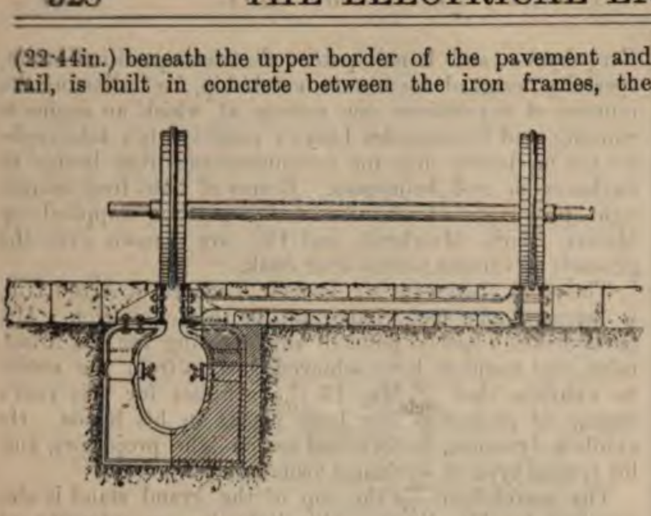

FIG. 1.—Section of Budapest Electric Tramway.

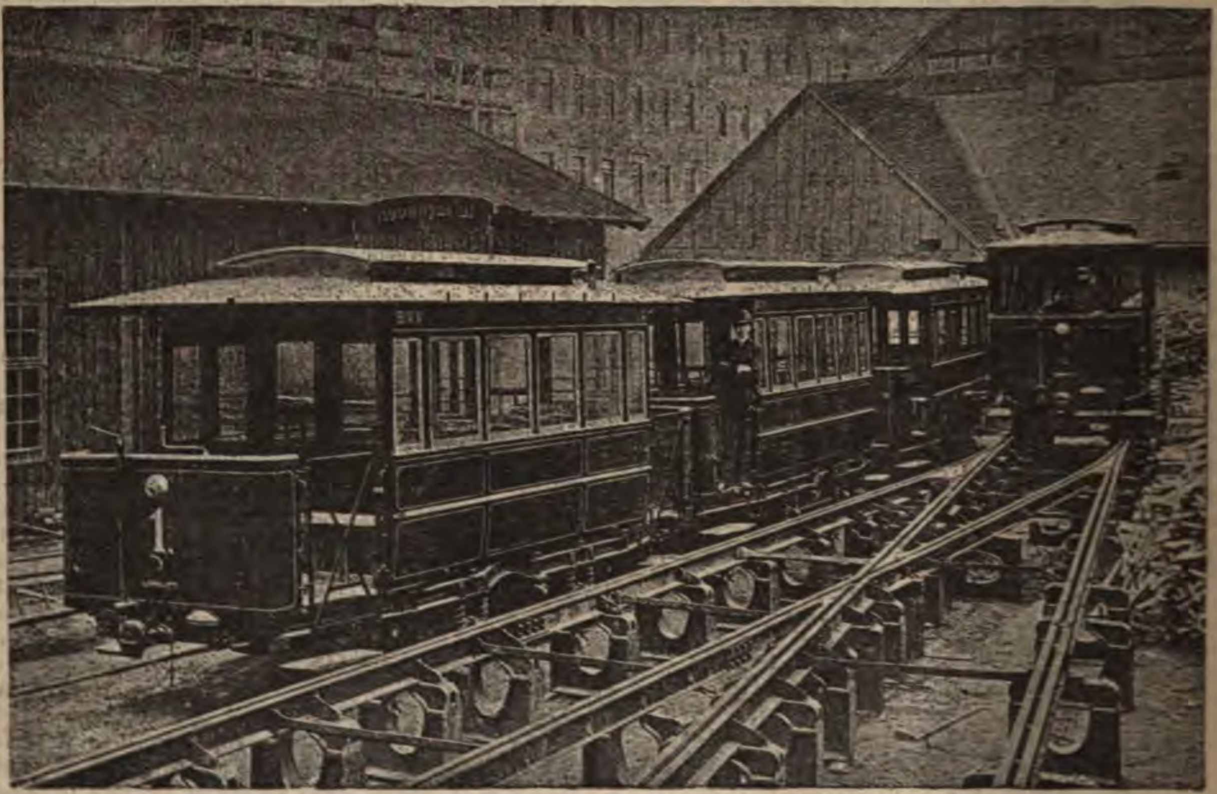

FIG. 2.—Underground Work of the Budapest Electric Tramway.

(22·44in.) beneath the upper border of the pavement and rail, is built in concrete between the iron frames, the frames being used as guides. The rails have the requisite strength to bear with safety any street loads occurring between the two supporting frames. The lateral pressure of the pavement, tending to straighten the gaps between the two single rails, is sufficiently provided for by the angular fishplates.

The second rail of the track has only a subordinate importance, as no conduit extends beneath it. It can be, therefore, carried out on any system, such as the Phœnix rail, as Vignoles rail without furrow, eventually even as a simple flat rail. In Budapest, for this second rail, the double tram rail of Haarmann has been used. Its two single rails are held together by bolts, and the two double rails of the line are connected together at intervals by track-rods, as shown in Fig. 1.

In the inner flanges of the iron frames, box-shaped insulators are inserted, carrying the electric conductors inside the conduit. The conductors consist of angular iron bars, which have, at a sufficient conductivity, the requisite strength to resist the wearing away caused by the friction of sliding contacts. The two conductors, one of which serves as lead and the other as return, lie perfectly protected beneath the rails, so that from without they can be neither seen nor touched. The conductors are situated so high above the bottom of the conduit that the surface-water collecting in the conduit can flow away beneath the conductors without coming into contact with them. Shaft drains, to admit the surface water, are arranged at intervals close to the conduit. The water, after being separated from any possible slime, flows out of these shafts into street drain. The bottom of the tramway conduit being only 70 cm. beneath the upper surface of the pavement, an injury to town drains and conduits is entirely excluded. On the other hand, a considerable advantage could be obtained over the ordinary tramway by employing a flat rail, as in this case, for each track there would be only a single furrow on the street surface. The appearance of the track in course of construction is shown in Fig. 2.

The electric car differs from the common horse tramcars only by the absence of the shafts, etc., instead of which it has at each of the two front sides a buffer that serves at need to couple several cars to a train.

Beneath the car, between the two axles, is placed the electromotor. The revolutions of its armature are transmitted by means of a chain gearing to one axle of the car, which thus becomes the driving axle. Fig. 3 represents such a motor and gearing, together with the two axles. The field magnets are made, as in the older construction of Siemens's machines, of flat iron bars, the considerations of a better use of material having been subordinated to the tendency of reducing the weight of the machine as much as possible.

The speed is regulated by four groups of resistances placed beneath the car platform. The switching in and out of these resistances is effected by means of a cylinder-shaped switching apparatus, which is situated in a case beneath the driver's seat, and which can be actuated from each end by means of a switch-crank there placed. The switch-crank allows the switching out and stopping of the motor as well as the reversing of its rotation.

This arrangement provides a very safe management of the car, which is one great advantage of electric over horse and steam traction. In case of danger the driver is enabled, by a simple rotation of the switch-crank, to reverse the movement of the motor, and, in connection with the operation of the brake, to bring about an almost instantaneous stoppage of the car. Among other advantages of the electric system may be mentioned the need of a very much smaller depot. In comparison with horse tramcars the electric car is shorter by the length of the team. In the same way an electric car is much smaller than a steam car of equal available seating space.

The current is led to the car motor by means of a sliding contact arm running between the two angle-iron conductors and carried forward by the moving car. The working pressure is 300 volts. Several cars can be run contemporaneously on the same track.

At Budapest there are at present in operation three lines with underground current conduction—namely, (1) the Stationsgasse line since the 30th July, 1889; (2) the Podmaniczkygasse line since the 10th of September, 1889; and (3) the great Ringstrasse line since the 6th of March, 1890. Besides these, there are (4) the Friedhof line in course of construction, for which electric propulsion by means of overhead conductors is in view; (5) the Königsgasse line already conceded; and (6) the Quay line in course of negotiation.

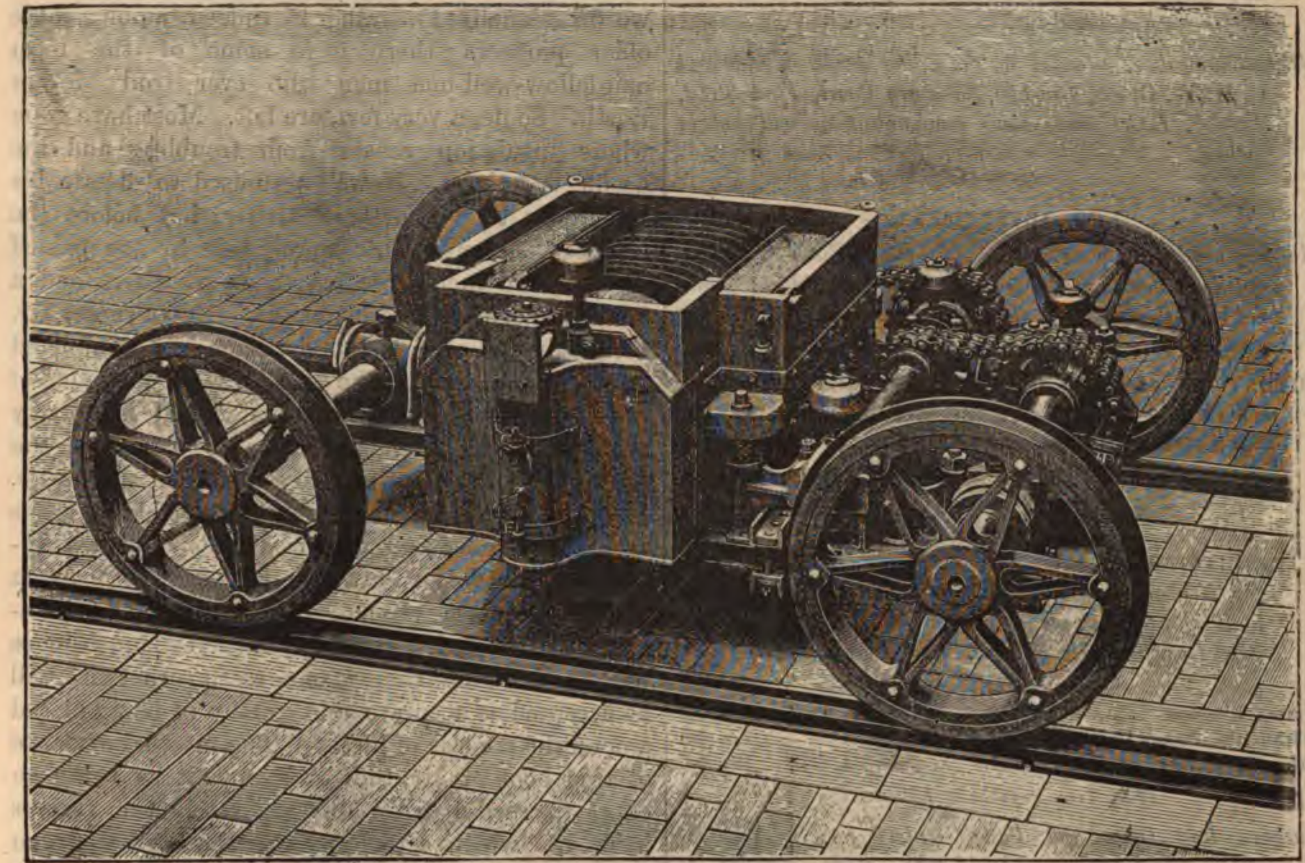

Fig. 3.—Tramway Motor for Budapest Electric Tramway.

The central station for furnishing the necessary working current is situated at 22, Hartnergasse. There are at present in use four steam boilers, each having 100 sq. m. (120 square yards) heating surface, three steam engines, each of 100 h.p., and three dynamos. The steam boilers are of tubular type, the steam engines are horizontal compound condensing engines, each of which drives a dynamo by means of rope gearing. The dynamos are connected to the collecting bars of the switchboard, from which the current is separately conveyed to the single railway lines by means of iron-sheathed patent lead-covered cables laid underground. There are three such feed conductor pairs, one of which leads to the crossing of the Podmaniczkygasse with the Ringstrasse, another to the crossing of the Stationsgasse with the Ringstrasse, and the third to the Ringstrasse corner of the Dohanygasse. The feed conductors terminate in junction-boxes placed at the three points mentioned, from which, by means of short conductors, the different rail-lines are separately supplied with current.

For sheltering and supervision of cars there are erected service stations at the end points of the two radial lines. The car-sheds are provided with two turnstiles, connected by rails with the Podmanicskygasse line. The car-shed is also in connection by means of the turntable with a repairing-shed for four cars, which contains the necessary machine tools for smaller repairs. These machines are operated by an electromotor fed from the tramway mains.

The rolling-stock includes at present 50 electric cars and eight spare cars. The working speed has been fixed by the city authorities as follows: The maximum speed is 15 kilometres (9·32 miles) per hour. In the outer Podmaniczkygasse it may be raised up to 18 kilometres (11·18 miles). On the other hand, in some of the narrower streets where there is much traffic, the speed is to be lowered to 10 kilometres (6·21 miles), and at crossings of main intercourse streets to 6 kilometres (3·73 miles).

In consequence of this greater working speed against that at horse tramways, the utilisation of the rolling-stock is also very favourable. Each car performs, at 16 hours' day service, 120 to 130, and even up to 150 car kilometres (respectively, 75 to 81, up to 93 car miles). In a technical respect, also, the Budapest railway has proved a perfect success. All arrangements, and particularly the neat underground arrangements, have proved excellent, and the Budapest railway may thus become a precedent for many other electric tramway plants in towns having much traffic.

The results of the working brought together in the following table are considered as exceedingly satisfactory:

Total Traffic Returns for all Three Lines since the opening to the end of December, 1890.

Lines in service.	Stationsgasse. Opening of service 30th July, 1889.	Podmaniczkygasse Opening of service 10th Sept., 1889.	Ringstrasse. Opening of service 6th March, 1890.	Totals.
Trips	114,838	91,051	110,156	316,045
Car kilometres	287,581	318,678	282,428	888,687
Passengers carried ...	1,684,220	914,431	2,325,379	4,924,030
Passengers per car kilometre	5·85	2·87	8·23	5·54

THE

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Specimen copies of the paper will be sent on request.

WILLOUGHBY SMITH'S MONOGRAPH.

In a recent issue, we casually referred to Mr. Willoughby Smith's new book on "The Rise and Extension of Submarine Telegraphy." Often have we urged the survivors of the pioneers of 1850 to put into book form their recollections and their notes, so that the world might have an authentic record of the initial work connected with submarine telegraphy. The late Dr. Whitehouse, in whose house we first saw a joint of the original Dover Straits cable, had a fund of reminiscences ; but he passed away without recording them. Genial T. R. Crampton, in his later years, turned his attention to other matters than submarine telegraphy ; and while always ready for a talk and a joke, could not be induced to put pen to paper. Dear old Crampton, how some of we younger men miss you when we occasionally foregather ! Indeed, among these older pioneers there were some of the most hail-fellow-well-met men who ever trod Mother Earth. Some, a very few, are left. Most have gone where insulation ceases from troubling and the needle is at rest. Newall promised to dictate his experience to a shorthand writer, but before the necessary arrangements were made he too passed away. Two men were left, each of whom had a fund of information to his hands. One of these, Mr. Willoughby Smith, has undertaken and completed the task, and given to the world a work the value of which can easily be underestimated. It is a pretty problem among mathematicians to arrive at the probability of the truth of any historical statement. Hearsay evidence is extremely improbable so far as accuracy is concerned, and needs independent corroboration before an historian views it with much favour. The description of scenes and incidents passing under the writer's own eyes carries much more weight, and, unless there is some reason otherwise, will be accepted as accurate, and worthy of being placed among the records of history. The internal evidence of this book of Mr. Smith's stamps it as being an effort to record truly and accurately the various incidents which came within the author's ken during the rise of submarine telegraphy. Those who have a personal acquaintance with Mr. Smith know, without further evidence being required, that his record is as true a record of the facts of the case as it is possible for humanity to obtain. No man is better qualified than Mr. Smith to write such a history. Mr. F. C. Webb, whom we have in mind, was connected with telegraphy as early, but his subsequent connection has not been so close as that of Mr. Smith, nor has his position been such as to place within his reach much of the information that is in the hands of his old colleague. Other names have been made more prominent, but no man has done more or better work than Mr. Smith in the early work of submarine telegraphy. Among the notes we have at various times made we will refer to two, upon the first of which we should like some enlightenment. It is a note published in January, 1847, to the effect that: "The South-Eastern Railway have exhibited their confidence in this invention (submarine telegraph) by making preparations to lay down an electric telegraph from Folkestone to Boulogne." How was this confidence shown, and what were the preparations made? We can trace nothing. The Bretts are not said to have had a hand in producing this confidence; nor can we find any record of communications with the French Government such as would be necessary and were carried out in the case of Brett. The full text of the concession to Brett and Co. we have never seen published. The following is the fullest information on the subject at our command: "The concession signed by Louis Napoleon and the Minister of the Interior, M. Dufaure, granting to Messrs. J. Brett, Toche, and Co. the right to establish an electric telegraph line between France and England, by a submarine communication across the Channel, has been authorised. The company propose to establish between the two countries an instant communication by means of the electric telegraph. The patentee guarantees that this telegraph shall, by the aid of a single wire and of two persons only (the one station in France, the other in England), be capable of printing in clear Roman type (on paper) 100 messages of 15 words each, including addresses and signatures, all ready for delivery in 100 consecutive minutes." Surely that was a tolerably large order for 1849 or 1850. Mr. Smith's book contains more proof, if more were necessary, of the absurdities perpetrated by men who pose as experts in the initial stages of the development of an industry. Once given the idea, and submarine telegraphy rapidly developed, principally through the aid of cruel experience. Cable after cable failed. The faults were traced and one by one remedied, till we have now arrived at a period of comparative perfection, within some forty years or so of the first cable being laid.

A NEW USE FOR THE ELECTRIC LIGHT.

Such is the title of a paragraph going the rounds of the daily papers, describing how the aid of the electric light was called in to prevent the death of various delicate plants during transportation from the West Indies to Kew. The memory of the ordinary journalist is very short, or reference would have been made to the late Sir W. Siemens's experiments. From time to time attempts are made to determine the influence of electricity upon plant life. Many experiments before the time of Siemens were made to find out the effect of a current upon plant or vegetable life, but so far as we know he was the first to satisfactorily substitute the electric for sunlight. In 1844 Mr. Ross described some experiments he made on potato-growing. According to his experiments, he is said to have obtained potatoes more quickly and of a much larger size when grown under the influence of a current. Similar results were obtained with cucumbers. In the annals of the Royal Institution for May 16, 1844, will be found a paper by the Rev. E. Sydney, "On the electricity of plants in the several stages of their development," in which he advances five propositions, one of which is to the effect that there are "indications of adaptation in the form of plants, in their various stages of development, to electrical influence." In October, 1844, a proposal was made, due to a paper read before the Tring Agricultural Association, to form an electro-cultural society. The paper referred to contained a description of experiments made by Mr. Forster at Findrossie, in Morayshire. Mr. Forster, it seems, reared, among other things, some Chevalier barley under electrical conditions, with the result of obtaining from 23 poles a yield of barley equivalent to 104 bushels per acre, the weight per bushel being 2¼lb. above the average, the straw being at the rate of 9,390lb. per acre. At this distance of time, and upon a subject that has been generally neglected, and about which at the time there were wide differences of opinion, it is difficult to decide how far the results of any of these experiments were due to electricity or to other causes. It always seemed to us, however, that Siemens s experiments pointed out the desirability of an exhaustive test as to how far plants and vegetables could be forced by supplying an artificial in addition to the natural light—that is, by extending the hours of light to the plant. Another series of tests might be carried out to prove or disprove the results of these earlier experimentalists as to the effect of a gentle electric current. It may be that under the action of even a non-measurable current certain chemical actions, decompositions or otherwise, take place which have a salutary effect upon plant life. As was said nearly half a century ago, "The agricultural questions remain to be solved; the data are at present so scanty, and the facts so disconnected, that nothing but experiment can serve our purpose." At or about this time (1844), Becquerel, Pouillet, Bachhoffner, Weekes, Thomas Pine, and others, were experimenting in this direction. These men used batteries, friction machines, Leyden jars, and what not. We have dynamos—whether they are better or worse remains to be seen. Pouillet, Becquerel, Coventry, Pearsal, Solly, Mechi, and others came to the conclusion there was much cry and little wool. Most of these repeated the experiments of Forster, but not with the same result, while Sturgeon communicated to the Royal Society an account of a successful repetition of this experiment.

BARNSLEY.

"The Board of Trade has killed the Barnsley electric lighting scheme." The foregoing sentence is the first in a short leader which appeared in the *Sheffield Daily Telegraph* of May 25th. It will be seen from the report of the Barnsley Council that this statement is hardly correct. For once, however, we are at one with the Board of Trade, and look upon this fiasco at Barnsley as just on a par with the boy who was told not to cheek his grandmother. The caution was unavailing, and the said boy felt a difficulty in sitting down for a few days. He paid the penalty—so must Barnsley, which was one of those towns to send a request broadcast for tenders. They got their tenders, with plans provided, plans which have broken down—whether because of Board of Trade action or not is immaterial. Had the Barnsley authorities gone to work in a proper manner, they would have spent less money and come to something definite. Now the Council is unfair to its surveyor. It is hardly to be supposed that that gentleman can draw up proper plans, plans that will pass the Board of Trade and be suitable for the lighting of the town. He might with more reason be asked to get out plans for a new town hall, instead of employing an architect, and would probably produce something more satisfactory than for electric lighting. Week by week the moral is being driven home—" Employ a competent consulting engineer."

THE ELECTRICAL TRANSMISSION AND CONVERSION OF ENERGY FOR MINING OPERATIONS.*

BY H. WARD LEONARD.

Until quite recently all practical methods of transmitting and converting energy involved the actual transfer of matter over the distance in question; and this matter necessarily possessed such qualities as weight, bulk, temperature, inertia, and other qualities common to all matter. It is, therefore, not surprising that all engineers, and particularly mining engineers, are watching with the keenest interest the development of methods for transmitting and converting energy by means of electricity; for in the electrical transmission of power the many restrictions due to the inflexible characteristics of matter may be entirely disregarded and the possibilities of mining engineering are correspondingly increased.

The transmission and conversion of energy by water, steam, cables, compressed air, etc., we are all familiar with, and we know to our sorrow the limited distance, the low efficiency, or the tremendous first cost which has hampered our engineering work at every turn. With the utilisation of electricity for the transmission and conversion of energy, we are enabled to operate at practically unlimited distances, with extremely high efficiency and very low first cost.

The invention of the incandescent lamp marks the commencement of an era in which the possibilities of engineering will be extended to a degree of which we can, at present, have no adequate conception. Until the Edison lamp was invented and introduced, all distribution of electrical energy was by what is know as the series system, which did not lend itself readily to the development and use of electric motors. With the Edison lamp came the system of distribution on the multiple arc plan, and the commercial development of electric motors dates from that time.

The stationary electric motor, supplied from the lighting circuit, was naturally the first to come into use, on account of the number and simplicity of its applications. Then the motor was applied to propelling street cars, and the modern electric street railway system was rapidly evolved. The electrical engineer, in his search for " new worlds to conquer," next turned his attention to the mining field. The great variety of the applications in this field, the distance from the mines to the principal cities where electrical developments have been most rapid, and the lack of knowledge as to the exact requirements have, until recently, made even the simplest applications of electricity to mining rather rare. Perhaps the greatest stumbling-block has been the percussion drill. When a mine owner asked if we could transmit his power, light his mine, and operate his pumps, hoists, tramways, and mills, we could confidently reply " Yes "; but until recently, when asked if we could replace or operate his air drills, we were obliged to say " Not yet." Since the drill is the most universal of all mining appliances operated by power other than hand power, it was not possible to make rapid progress until this deficiency was corrected.

The Edison General Electric Company has put upon the market in commercial form, during the past 30 days, three types of electric drills which will enable the mining engineer to accomplish all that he has been able to accomplish heretofore by other drills; and not only this, but to accomplish far more than was heretofore possible, and under conditions heretofore prohibitory.

THE ELECTRIC PERCUSSION DRILL.

First in importance comes the electric percussion drill, the invention of Mr. H. N. Marvin, of Syracuse, N.Y. The following is a brief description of the principal features of this drill:

Fastened upon a suitable tripod or column is a piece of boiler tube 7in. in diameter and about 2½ft. long. In the forward half of this casing are placed two hollow cylindrical coils of wire in the form of solenoids, each about 8½in. long, having an outside diameter of about 6¾in., so as to make a loose fit with the casing, and an inside diameter of about 2⅛in. These two solenoids are placed so as to be against each other end to end in the casing. The bit plunger plays freely through the centre of these solenoids, and is supported by two bearings placed just beyond the outside ends of the two solenoids respectively. The back portion of the casing contains a spiral spring of the form frequently used for car springs. The plunger is composed of a central portion made of wrought iron about 14in. long, and both the forward and back portion of the plunger, which are made of aluminium bronze, are rigidly fastened to this iron portion. The forward portion is about 13in. long, and carries the bit socket. The back portion is spirally milled for a length of about 9in., so that the cross-section of this portion is hexagonal. At the extreme back end is a steel buffer which strikes against the cushioning spring. The spirally milled portion of the plunger is similar to that used in other percussion drills, and causes the drill to revolve upon its axis one-sixth of a complete turn with each stroke.

The ends of the coils of wire are brought to contact-pieces at the top of the adjacent ends of the two solenoids, where there is a socket for receiving the terminals of the cable, and thus making electrical connection with the drill. There are three conductors leading from the generator to the drill, one of which is connected to one terminal of each of the solenoids, and the other two conductors are connected to the two remaining terminals of the solenoids respectively.

The generator is of the simplest kind, the coils on the armature having their terminals connected to two insulated collars on the shaft. One collar is a continuous metallic ring, and upon this rests a brush which is connected with that conductor which is common to both solenoids. The other collar is metallic for half of the circle, and the remaining half is insulated from the armature wires. Upon this half ring rests two brushes diametrically opposite each other, and each brush is connected to one of the two remaining conductors leading to the solenoids in the drill.

If we now revolve the armature of our generator in a separately excited magnetic field, an electric current will flow from the armature to the half ring, then through one of the two brushes which happens at the instant to be in contact with the half ring along the corresponding conductor to one terminal of one solenoid, let us suppose the rear one, then through the rear solenoid itself and back along the mutual wire to the continuous ring and then to the armature again. This current in passing through the rear solenoid makes a powerful magnet of it, and this tends to pull the plunger back into such a position that the centre of its iron portion will be in the centre of the rear solenoid.

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* Paper read before the Association of Mining Engineers of Quebec.

When the armature moves forward a half revolution, the polarity of its wires is reversed, and the other brush with its conductor is now in contact with the half circle. Consequently, the current in the mutual wire will be in the reverse direction from that of the former wave. The rear solenoid and its conductor, formerly active, are now out of circuit; and the circuit is made through the other conductor and its corresponding solenoid—that is, the forward solenoid.

The magnetic action of this solenoid now tends to make the plunger move forward so that the centre of the iron portion shall be in the centre of the forward solenoid.

Thus we get a reciprocating action of the plunger, and every revolution of the armature of the generator will cause a complete stroke of the drill. By varying the speed of revolution of the generator we can make the drill strike any number of blows per minute we choose. In usual practice 600 blows per minute is found to give excellent results. The spiral spring, it will be observed, stores up the energy of the back stroke, and returns it to the forward stroke, assisting the magnetic impulse and greatly increasing the strength of the blow.

In order that we may form an unbiassed judgment of this drill, I will quote the opinion of André, perhaps the best authority on power drills, who many years ago stated the desirable qualities in a first-class power drill to be as follows:

1. Simplicity of construction and strength in every part. 2. A small number of parts, especially moving parts. 3. Minimum weight consistent with strength and simplicity. 4. Minimum bulk. 5. Striking part of great weight compared with the rest of the drill, and striking directly. 6. Piston alone exposed to shocks. 7. Piston capable of variable length of stroke. 8. Ability to withstand without injury the sudden removal of the resistance. 9. Automatic rotary motion. 10. In automatic feed drills, feed regulated by the advance of the piston as the cutting advances. 11. Capability of working with moderate pressure. 12. Readily taken to pieces.

It may be sufficient to say that the Marvin drill possesses everyone of the good qualities André specifies, and in a most marked degree; but in describing the good qualities of this drill, we can, if necessary, add considerably more than André specifies. For example:

1. It is simple in construction and strong in every part. 2. It has a minimum of moving parts—that is, one. 3. It is very light in weight for its strength, this being possible because of the perfect cushioning at both ends of the stroke. 4. It takes up very little space. 5. The striking part is of relatively great weight and it strikes directly. 6. The length of the stroke is variable at will. 7. The drill cannot damage itself by its own blow. 8. The rotary motion is automatic. 9. It has very few parts. 10. It can be entirely taken apart and put together again inside of 10 minutes. 11. There are no joints to be fitted or packed. 12. It is not affected by heat or cold. 13. It can be operated at great distances from the source of power. 14. It has a much higher efficiency than other drills. 15. It is independent of the action of any valve. 16. The rate of striking is independent of the kind of material it strikes. 17. It will operate in the open air without striking anything, and hence can be made to strike an extremely light blow at its full rate, which is very important in starting holes, etc. 18. It can be rapidly moved from one position to another at a great distance, since the energy is transmitted through flexible cables. 19. No loss is suffered due to elbows, bends, valves, etc., in the conductors. 20. The conductors can be carried on very light supports, both because of their light weight and because the transmission of energy through them does not tend to distort their position.

The importance of the above characteristics will be apparent to anyone who is familiar with the operation of steam and air drills. It is interesting to note that in driving the Hoosac Tunnel the average life of the power drills before sending them to the shop was 50 hours. Even to-day, after a development of 25 years, we find that it is common practice to have in the shop one-half the total number of drills employed.

(To be continued.)

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING, MEMBER.

(Continued from page 511.)

16. In order to examine the phenomena of these trunk mains more closely, some experiments were made on one long length of nearly 12 miles of the cable, by joining the conductors of two trunk mains in London and having both ends of this gigantic loop of concentric cable at our disposal in the Deptford station. These experiments were arranged by Mr. Ferranti to give Mr. Preece, Major Cardew, and me the opportunity of obtaining measurements of these condenser effects in the Ferranti trunk mains. The experiments were made on Friday, January 9, 1891, at Deptford, and Mr. Ferranti, Mr. Sparks, Mr. D'Alton, Mr. McLean, and the assistant engineers took part in carrying out these measurements. The arrangements were made as follows (see Fig. 10): One of the 1,200-h.p. dynamos (No. 2) was set apart for the purpose, and excited so as to supply current at about 2,500 volts or so. The current from this dynamo was led through the primaries of two 150-h.p. transformers joined in parallel, and which raised the pressure from 2,500 to 10,000 volts. At this pressure a current from the secondaries was sent into the concentric cable at Deptford, thence to the sub-station in Trafalgar-square in London by one main, and back to Deptford on the other trunk main. This total distance is 20,224 yards, or 11·49 statute miles. Arriving back at Deptford, the current was again reduced from 10,000 to 2,500 volts, and the energy taken up in water resistance in a water tank at the latter pressure. The pressure at different parts of the system was measured by Cardew voltmeters, the high pressures being reduced by 100 : 1 pilot transformers. The currents were measured by Evershed ammeters. The current and pressure were measured at four places—viz., at the terminals of the dynamo at the beginning, or entrance, of the trunk main, at the end of the trunk main, and, after reduction, at the tank. Observers stationed at these different instruments took simultaneous observations at a signal given by the sound of a whistle, and in this way the simultaneous values of the pressure and current were obtained at these four places. The transformers used for raising and lowering the pressure were the 150-h.p. size, having on the primary side 1,120 turns of wire, of resistance 3·5 ohms, and on the secondary side 280 turns of wire, having a resistance of ·2442 ohms. Hence these transformers were 4 : 1 transformers. There were, in addition, a pair of pilot transformers, which had a change ratio of 100 : 1, and which reduced from 10,000 to 100 volts for voltmeter purposes. The observations consisted in exciting the dynamo to various voltages, and observing the current and pressure at the four places named, whilst different loads were placed on the system by taking up more or less current in the tank.

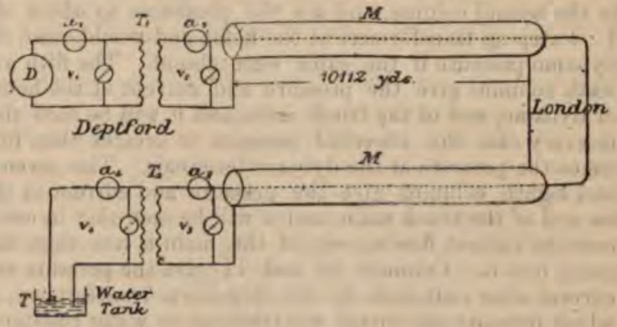

FIG. 10.—v_1, v_2, v_3, v_4, Voltmeters. a_1, a_2, a_3, a_4, Ammeters. D, Dynamo. T, Tank. T_1, Step-up Transformers. T_2, Step-down Transformers. M, Trunk Mains.

17. From a large number of observations the following are selected as showing the general results obtained, and

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* Paper read before the Institution of Electrical Engineers, May 7, 1891.

TABLE I.—EXPERIMENTS ON THE PRESSURE DISTRIBUTION IN THE FERRANTI TRUNK MAINS.

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
No. of experiment.	At dynamo terminals.		Dynamo pressure multiplied by 4.	At home end of trunk main.		At far end of trunk main.		Pressure at tank multiplied by 4.	At the tank.	
	Pressure.	Current.		Pressure.	Current.	Pressure.	Current.		Pressure.	Current.
1	2,177	121·4	8,708	9,060	29·2	8,950	26·5	8,640	2,160	118·2
2	2,386	119·4	9,544	10,100	31·5	9,770	28·0	9,504	2,376	117·1
3	2,458	119·4	9,832	10,300	32·0	10,120	28·0	9,840	2,460	116·0
4	2,177	119·3	8,708	9,110	29·2	8,930	26·5	8,640	2,160	116·0
5	2,311	113·2	9,244	9,700	28·7	9,570	24·8	9,408	2,352	106·5
6	2,251	110·2	9,004	9,600	27·6	9,280	24·3	9,024	2,256	105·5
7	2,568	106·1	10,272	10,490	27·0	10,070	23·3	9,792	2,448	101·6
8	1,994	108·1	7,976	8,420	26·0	8,200	23·3	7,872	1,968	100·7
9	2,448	100·0	9,792	10,170	24·0	10,690	19·0	10,128	2,532	56·6
10	2,496	92·8	9,984	10,560	22·0	10,590	17·0	10,512	2,628	56·0
11	2,400	92·8	9,600	10,360	21·5	10,490	16·3	10,224	2,556	55·5
12	2,311	64·1	9,244	9,700	17·0	9,770	Not taken	9,600	2,400	42·2
13	2,280	41·7	9,120	9,870	11·0	9,900	0	9,736	2,434	0
14	2,328	41·7	9,312	9,970	11·0	10,000	0	9,880	2,470	0
15	1,620	42·7	6,480	7,240	10·0	7,350	0	7,248	1,812	0
16	1,104	24·4	4,416	5,200	5·0	5,200	0	4,964	1,241	0
17	1,212	24·4	4,848	5,500	9·0	5,500	0	5,456	1,339	0
18	1,308	24·4	5,232	5,900	9·0	5,900	0	5,740	1,435	0
19	1,800	37·6	7,200	7,920	10·0	7,920	0	7,784	1,946	0
20	2,136	48·8	8,544	9,380	12·0	9,410	0	9,244	2,311	0

are set forth in Table I. The first column gives a number for each experiment. The second and third give the pressure and current at the dynamo terminals. The fourth column is a series of numbers which are four times those in the second column, and are the pressures to which the 1 : 4 step-up transformers at the home end would raise the dynamo pressure if the cable were absent. The fifth and sixth columns give the pressure and current at the home, or dynamo, end of the trunk main, and it will be seen that in every case this observed pressure is greater than four times the pressure at the dynamo terminals. The seventh and eighth columns give the pressure and current at the far end of the trunk main, and it will be seen that in every case the current flowing out of the main is less than that going into it. Columns 10 and 11 give the pressure and current after reduction by the step-down transformers, at which pressure the energy was taken up on water resistance in a tank. Column nine gives the pressure on the primary, or cable, side of the 4 : 1 step-down transformers, which would be necessary to give the pressure observed at the tank if the cable were not present.

18. We have then to see how these observed values agree with theory. It must be, however, stated that these numbers and values so observed are not minutely accurate. Owing to the fact that the speed of the dynamo varied slightly, and to the fact that the Cardew voltmeters used were set vertical, and not horizontal, some degree of inaccuracy exists in the readings of current and pressure, but the figures are perhaps sufficient to test the general agreement of fact with theory.

We note, first, that in the experiments at full load, when 118 amperes was being taken up in the resistance, the load on the transformers was about 340 h.p., and hence the two 150-h.p. transformers at each end joined in parallel were slightly overloaded. Under these circumstances, the inductance of the transformers at the step-up end is reduced practically to a very small value, and we may consider that the actual current of 30 amperes or so flowing in the cable can be considered to be the resultant of two superimposed currents differing about 90deg. in phase from one another. There is, first, the work current of 26·5 amperes in Experiment I., which is flowing out of the cable, and which is practically in synchronism with the impressed E.M.F. in the secondary circuit of the step-up transformers. Then there is the condenser current of the cable considered as one single condenser, which will be 90deg. in advance in phase of the impressed E.M.F. creating this charge. Hence the values of the ingoing currents given in column VI. are the resultants of the outgoing currents given in column VIII., and the condenser current of the cable, which is in quadrature with the last. Hence the magnitude of the condenser current must be the square root of the difference of the squares of the currents given in columns VI. and VIII., which may be called respectively the resultant current and the work current.

Taking the first six experiments in Table I., we calculate from them the square root of the difference of the squares of the currents in columns VI. and VIII. of Table I., and write them as in Table II.

TABLE II.

Resultant current going into cable $= a$.	Work current coming out of cable $= b$.	Condenser current of cable $= \sqrt{a^2 - b^2}$.
Amperes.	Amperes.	Amperes.
29·2	26·5	12·2
31·5	28·0	14·4
32·0	28·0	15·5
29·2	26·5	12·2
28·7	24·8	14·4
27·6	24·3	13·1

Unfortunately, the speeds of the dynamo were not taken at each observation; but the normal frequency of the current from these dynamos is 67, and in these experiments the dynamo speeds were marked as rather below the normal. If $n = 67$, $2 \pi n = p = 421$. It is probable that the value of p was not greater than 400 in these experiments. We have seen (equation 2, *ante*) that if v is the instantaneous potential difference of the condenser terminals, and i the current flowing into it at any instant, $i = C \frac{dv}{dt}$. Hence, on the assumption of a simple periodic variation of the current, we may write p for $\frac{d}{dt}$, and put as the value of the square root of the mean square of the condenser current, I, the expression,

$$I = p C V,$$

where C is the capacity, and V is the potential difference of the terminals of the condenser as read by an electrostatic or Cardew voltmeter. It then follows that the capacity of the cable is determinable from the values of the condenser current, I, the pressure, V, as read at the step-up end, and from the known value of p.

(To be continued.)

INSTITUTION OF ELECTRICAL ENGINEERS.

ON THE MOST ECONOMICAL MODE OF FEEDING A LOW-PRESSURE NETWORK.

BY R. E. CROMPTON, VICE-PRESIDENT.

The advocates of alternating transformer (hereafter called the A.T.) system of distribution, appear at last to be in agreement with those who designed low-pressure systems, in that they admit that for the supply of towns of ordinary compactness a low-pressure network must be provided,

TABLE I.—COMPARISON OF COST OF 100-KILOWATT FEEDERS.

—	A. 220-volt low-pressure feeder. Mean annual efficiency, 90 per cent. 450 yards bare copper ; 150 ,, cable in pipes ; total 600 yards.	B. 220-volt low-pressure feeder. Mean annual efficiency, 90 per cent. 1,800 yards bare copper ; 600 ,, cable in pipes ; Total, 2,400 yards.	C. 2,000-volt A.T. feeder, with transformer in pit. Mean annual efficiency, 90 per cent. 2,400 yards concentric cable, laid in part of low-pressure culvert or in open.
	£	£	£
Excavation, or extra width culvert and pipes, at 5s. per yard	150	600	600
Transformer pit	—	—	60
Bare copper, at £90 per ton, laid	78	1,260	—
Low-pressure cable, 250 volts, rubber insulation, laid	65	1,020	—
High-pressure cable, concentric, 2,000 volts, laid	—	—	1,300
Transformer and apparatus, including fixing	—	—	440
Total	£293	£2,880	£2,400

TABLE II.—COST OF UPKEEP OF 100-KILOWATT FEEDERS.

—		A.	B.	C.
		£ s. d.	£ s. d.	£ s. d.
Culvert and pipes, etc.,	at 1 per cent.	1 10 0	6 0 0	6 0 0
Transformer pit,	,, 2½ ,,	—	—	1 10 0
Bare copper,	,, 1 ,,	0 15 8	12 12 0	—
Low-pressure cable,	,, 8 ,,	5 4 6	81 10 0	—
High-pressure cable,	,, 8 ,,	—	—	104 0 0
Transformer and apparatus,	,, 10 ,,	—	—	44 0 0
Small apparatus		2 10 0	10 0 0	10 0 0
Interest on total, 5 per cent.		14 13 0	144 0 0	120 0 0
Total		£24 13 2	£254 2 0	£285 10 0

Their practice in the future is to diverge from their practice in the past, in that they fix the transformers only at the feeding points of the network, instead of in each of the consumers' houses. In other words, they propose to use high-pressure feeders, consisting of cables carrying a high-pressure primary current, transformed so as to supply a low-pressure network on either the two or three wire system, by a transformer fixed at the feeding point. Mr. Ferranti, Mr. Gordon, and other gentlemen advocate banking the transformers at these feeding points, and the use of automatic apparatus to switch their transformers in as the load requires. Others, such as Mr. Mordey, prefer to spend more money on the perfecting of a design of a single transformer at the feeding point, so as to avoid the complication of automatic apparatus. As it was evident that there is a certain length of feeder at which the low-pressure direct system fails to compete successfully in first cost and that of upkeep with the above described high-pressure A.T. feeder, I have recently investigated the question in order to find out at what mean length of feeders the low-pressure and high-pressure systems compete on equal terms of first cost, cost of upkeep, and efficiency. The result of my investigation is to show that when a three-wire low-pressure system, distributing direct to 110-volt lamps, is compared with an A.T. system, distributed by 2,000-volt feeders, transformed to supply the same three-wire network, the average annual efficiency of the feeders in both cases being 90 per cent., the low-pressure feeder is cheaper for all distances up to 2,400 yards, each of the feeders being calculated to supply 100 kilowatts; and the annual cost for upkeep, including a sum of 5 per cent. for interest on the capital, will be about £290 per annum. These large figures lead me to compare with them the known cost of upkeep of feeders carrying the same load which are now in use in London. I find that feeders of an average length of 600 yards cost about £300 each, and for interest and upkeep £25 per annum. This comparison shows that if we increase the length of each feeder by 1,800 yards, or say one mile, it increases the supply company's annual upkeep charges by not less than £260 per annum per feeder. If we apply these figures to a company supplying a district of about a square mile, which, if it had within it two generating stations, could feed its network with 10 short feeders, and substitute for these two central stations one external generating station one mile distant from the outside of the district, the extra cost of upkeep of the 10 long feeders will be £2,600 per annum. At a load factor of 10 such a district would sell 876,000 units per annum; therefore the above sum of £2,600, divided by this number of units, is equal to 0·72 of a penny per unit sold. Now even at present the cost per unit for coal and ground rent (which are the only two items affected by the removal of the site from a central position to a distant point) only slightly exceeds 1d. a unit, and in all probability during the present year this figure will be brought down to a sum approximately the same as the above-mentioned upkeep of the feeders—viz., 0·72, which I have shown is the actual cost of upkeep of the feeders only. This shows the absurdity of imagining that any saving can be effected by this mode of feeding a network, and it is quite evident that those who have advocated the system have never seriously looked at the matter from this point of view. In such cases, where really great savings can be effected by generating the energy at a distance from the district to be supplied, as in the case of water power, Mr. Ferranti's original Deptford scheme of supplying one or two large transformer stations by currents of very high E.M.F. is in all probability the right one; but the distribution must be modified from Mr. Ferranti's original intention: that is to say, he need not transform twice, but merely supply several transformer stations by his high-pressure mains, and feed the surrounding districts by not only a low-pressure network, but also low-pressure feeders. I have not at command the figures as to the cost of mains of extreme high pressure such as Mr. Ferranti advocates; but I have no doubt that he will be able to show, even for such distances as one or two miles, a very considerable saving on the separate feeder system that I have just criticised.

Table I. shows you the details of first cost of the 600 yards low pressure, 2,400 yards low pressure, and 2,400 yards A.T. feeder with transformer.

Table II. shows the details of cost of upkeep of the same three feeders. It will be noticed I have taken the cost of upkeep on excavation or concrete work below ground at 1 per cent. per annum, on the transformer pit at 2½ per cent. per annum, on the bare copper at 1 per cent., on both low and high pressure cables at 8 per cent.; although I might well claim that the cost of upkeep of the high-pressure cable would be a higher percentage on its first cost than the low. The transforming and switching apparatus I have taken at 10 per cent., and I have added a small charge for the upkeep of surface and inspection boxes.

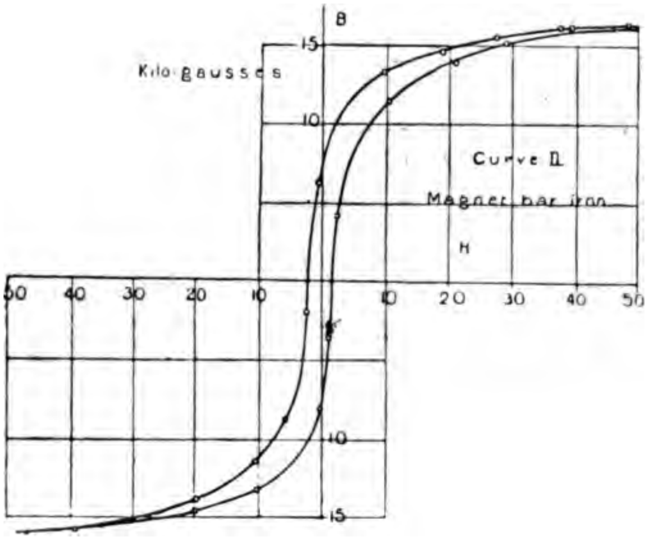
This is taken without reference to pressure, in proportion to the length laid. The cost of the low-pressure feeders has been carefully taken out in accordance with our London practice, and that of the high-pressure feeder has been taken out from estimates received from cable and transformer makers. I believe that these figures may be said to be sufficiently correct to make the comparison a fair one; at any rate, I think no one will venture to say that either the first cost or upkeep is taken at too high a figure. For the purposes of my argument they are sufficient to show that 100-kilowatt feeders of 2,400 yards long cannot be put down at less than £1 a yard, and cannot, including transformers, be maintained at less than 2s. 4d. a yard per annum.

SOME RESEARCHES IN ELECTROMAGNETIC INDUCTION.*

BY E. B. VIGNOLES.

(Concluded from page 505.)

In the following tables I give you the actual figures of some typical results:



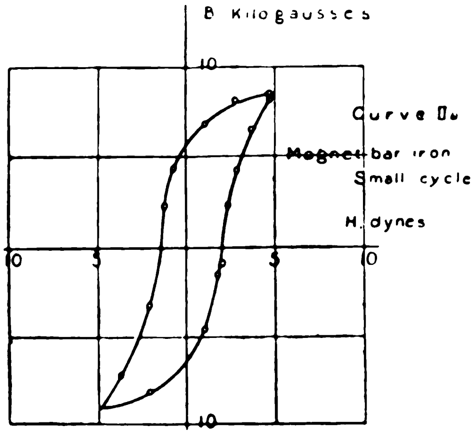


TABLE II.—Magnet Bar Iron.
Average length = 35 cm. Sectional area = ·877 sq. cm.

	Rising.		Falling.	
No.	H	B	H	B
1	—39·5	—15·55	48·3	15·8
2	—29·6	—15·1	38·5	15·4
3	—19·75	—14·5	28·6	15·05
4	— 9·9	—13·4	19·75	14·4
5	— 0·4	— 7·75	9·9	13·2
6	+ 1·0	— 3·7	— 0·6	6·9
7	+ 3·0	+ 4·4	— 2·0	— 2·0
8	+ 9·9	+11·8	— 4·9	— 8·9
9	+20·7	+14·0	— 9·9	12·15
10	+29·6	+15·0	—29·6	—14·95
11	+39·5	+15·6	—39·5	15·55
12	+48·3	+15·8	—	—

TABLE IIA.—Same Ring, Small Cycle.

	Rising.		Falling.	
No.	H	B	H	B
1	—2·0	—7·7	5·0	8·5
2	+0·79	—4·6	2·8	8·0
3	1·6	—1·6	1·0	6·8
4	1·8	—1·05	—0·7	4·7
5	2·5	+2·7	—1·2	2·7
6	2·8	4·0	—1·6	—0·1
7	3·7	6·5	—2·0	—3·0
8	5·0	8·2	—3·5	—7·0

TABLE III.—Charcoal Iron, with Scale on.

	Rising.		Falling.	
No.	H	B	H	B
1	—48·3	—15·2	55·1	15·2
2	—40·2	—15·0	12·7	13·2
3	—21·8	—14·3	4·6	11·6
4	— 4·6	—12·5	0	9·0
5	— 0·6	—10·9	— 1·9	— 0·4
6	± 0	— 9·2	— 2·9	— 5·3
7	+ 2·9	— 0·2	— 6·9	—10·6
8	6·9	+ 9·6	—10·4	—11·9
9	11·5	11·9	—30·1	—14·8
10	47·1	14·8	—	—

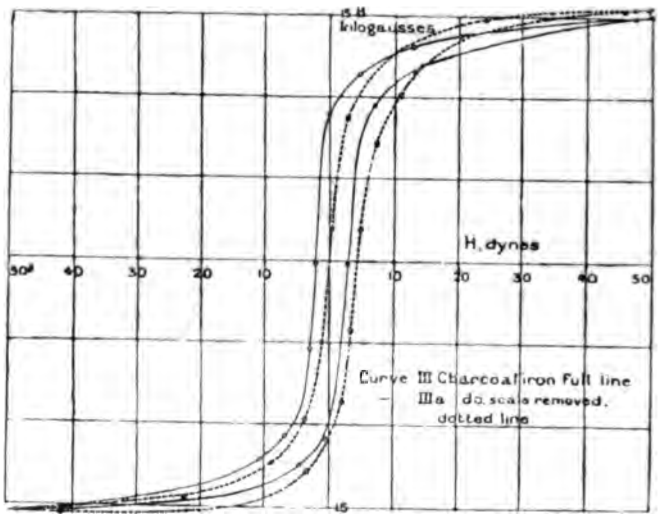


TABLE IIIA.—Same Ring, Scale removed by Acid.

	Rising.		Falling.	
No.	H	B	H	B
1	- 32·4	- 15·2	55·3	16·2
2	- 2·5	- 12·5	23·4	14·7
3	+ 2·0	- 8·0	9·0	12·6
4	+ 3·2	- 3·8	3·2	8·7
5	+ 4·4	+ 1·75	0·4	1·85
6	6·4	6·8	± 0	+ 0·6
7	8·8	9·9	— 1·2	— 5·1
8	12·4	12·1	— 3·7	— 9·8
9	18·2	13·5	— 8·6	—12·6
10	31·9	14·8	—22·2	14·5
11	56·0	15·8	—39·9	—15·2

The apparent increase in permeability is accounted for exactly by supposing the scale to have no permeability. Its removal decreases the area, and therefore increases the apparent **B**.

Note in the second curve, No. IIIA, the displacement of the curve with regard to the zero of magnetising force. We have not been able hitherto to account for this phenomenon satisfactorily. We have found it in several curves, the displacement being in some cases very large. It is perhaps due to a bias in the iron produced by a previous very high magnetising force in the direction of displacement.

TABLE IIIB.—The same Material, another Ring. Average Force-Induction Curve, obtained by Reversals, for High Magnetising Forces.

No.	H	B	No.	H	B
1	10·0	12·0	6	96·0	15·9
2	20·0	13·4	7	110·0	16·0
3	39·8	14·4	8	132·0	16·4
4	61·2	15·1	9	158·0	16·6
5	84·0	15·6	10	179·0	16·9

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* Paper read before the City and Guilds of London Institute Old Students' Association, May 13, 1891.

TABLE IIIc.—Charcoal Iron. Smaller Cycle.

No.	H	B
1	−3·81	−6·7
2	−1·77	−6·3
3	−0·41	−5·86
4	+0·97	−5·0
5	1·87	−3·22
6	2·36	−0·5
7	3·04	+2·4
8	3·72	4·6
9	4·42	6·3
10	4·6	6·65

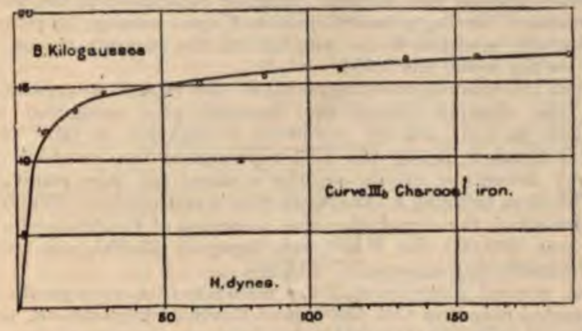
Hysteresis loss: 4,650 ergs per cubic centimetre per cycle.

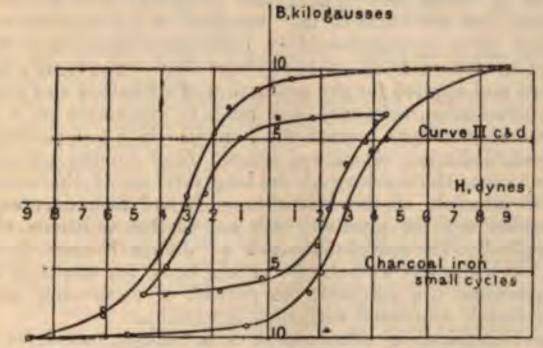
TABLE IIID.—Same Ring.

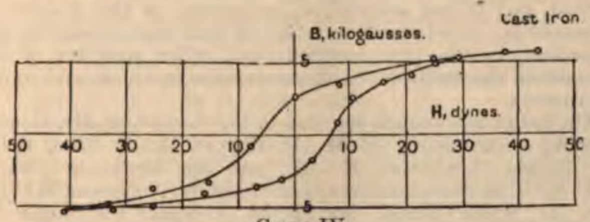
No.	H	B
1	−9·0	−10·3
2	−5·16	−10·0
3	−0·8	− 9·1
4	+0·5	− 8·1
5	+1·4	− 7·1
6	+2·0	− 5·2
7	+3·0	− 0·2
8	+4·0	+ 3·9
9	+4·45	+ 5·0
10	+6·1	+ 8·2
11	+8·4	+10·1
12	+9·0	+10·3

Hysteresis loss: 9,930 ergs per cubic centimetre per cycle.

This curve may be folded back to form the falling curve, as we have found that taking the falling curve by "breaking" methods gives too small an area, owing to causes which hardly come within the scope of this paper.







Curve IV.

I have given the falling curves obtained by carrying the iron through the cycle to the required point on the downward curve and then breaking P_2; but since taking them we have discovered the reason of their "humpbacked" appearance. In nearly every case, the falling curve comes down more perpendicularly than the rising curve, and for getting the hysteresis area more accurately it is best to fold over the rising curve. The iron cannot know which way round it is.

TABLE IV.—Cast Iron.
Average length = 32·6 cm. Area = 0·88 cm

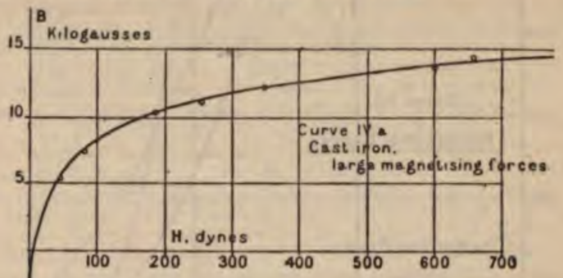
	Rising.		Falling.	
No.	H	B	H	B
1	−32·3	− 5·4	43·7	5·7
2	−24·5	− 5·1	33·2	5·3
3	−15·7	− 4·6	24·9	4·75
4	− 6·6	− 3·97	16·6	4·3
5	− 1·7	− 3·36	8·3	3·66
6	+ 3·3	− 2·2	± 0	2·55
7	7·5	+ 0·5	− 8·3	− 1·0
8	10·4	+ 2·0	−16·6	− 3·4
9	15·7	3·4	−24·9	− 4·5
10	20·7	4·1	−33·2	− 5·16
11	28·2	5·0	—	—
12	37·3	5·44	—	—
13	43·5	5·7	—	—

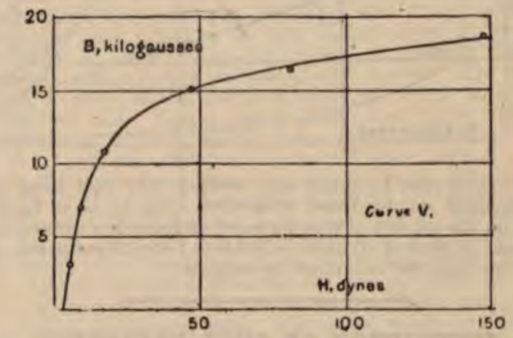
TABLE IVA.—Same Ring, Rising Curve for High Magnetising Forces.

No.	H	B	No.	H	B
1	3·0	−2·9	5	266	11·5
2	47	+6·4	6	353	12·3
3	91	8·4	7	596	13·9
4	178	10·3	8	662	14·6

These curves only give an idea of the behaviour of cast iron. This material is very variable in its magnetic properties. Other specimens have given higher permeability.

I will now give you the result of a test of a specimen of mild cast steel from Langley Mills, Nottingham. Note that for large magnetising forces its permeability is nearly as great as wrought iron. The observations are by reversal method, as the hysteresis area was not required. The steel was not annealed.





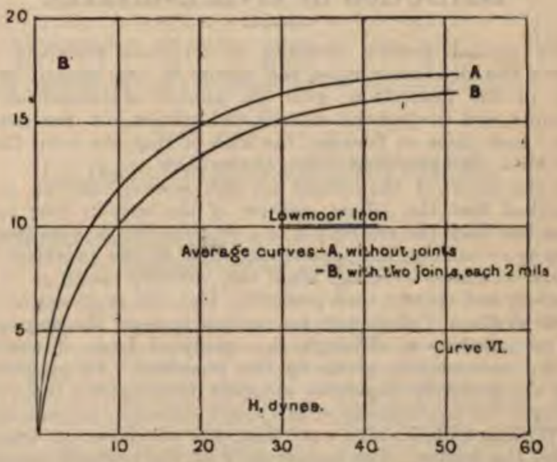


TABLE V.—Mild Cast Steel.
Average length = 43·3 cm. Area = 1·156 square cm.

No.	H	B	No.	H	B
1	5·15	3·1	5	82·5	16·6
2	8·75	7·0	6	148	18·2
3	17·3	11·2	7	240	19·0
4	48·8	15·2	8	288	19·9

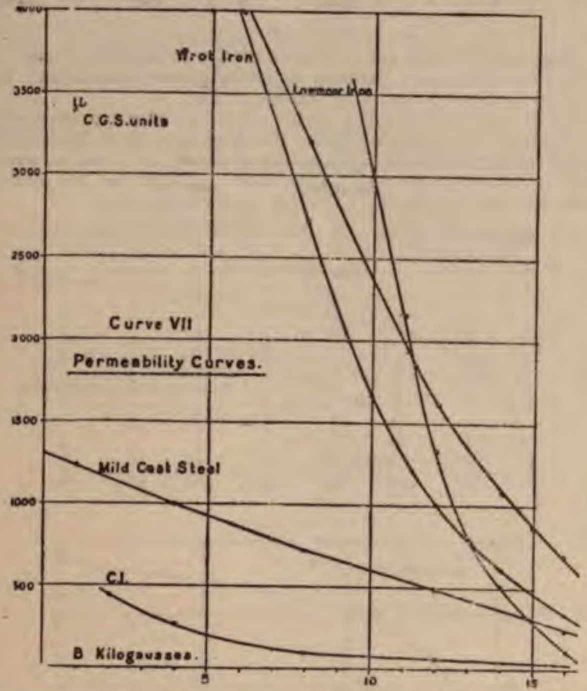
Curve VI. shows the result of introducing air gaps amounting to $\frac{4}{1000}$in. in a Lowmoor iron ring of 1·13 sq. cm. area, and 31·4 cm. long. It was obtained (the A curve) from a continuous ring, which was then sawn through, and the gap refilled by a piece of the same material, grain in the same direction. Thus treated the curve fell to B, a difference even at large induction densities of 5 per cent. or so.

Curve VII. exhibits in a comprehensive manner the results of the tests, taking average permeability, and as far as dynamos are concerned these curves give all the information necessary.

The above curves embody practically every material which we have tested.

I could say much as to interesting side issues which have cropped up in the course of the research, but I have thought it best to keep strictly within the lines laid down at the commencement—a description of our method and the results obtained by it.

Even as I write this I see the bearing of much of our work upon such vexed questions as the supposed "Mordey effect" (the decrease of hysteresis at full load), viscous hysteresis, and so on. But I should open so vast a subject and one on which so little is known, if I were to be led off to these subjects, that I think these questions must be reserved, I hope, for a future paper.



At the same time I cannot help stating here that some of the points brought out by these researches seem to us to have vital bearing on the subject of transformers, and also to a certain though less extent on that of dynamo armatures; and these points it will now be our business to further investigate.

INSTITUTION OF CIVIL ENGINEERS.

The annual general meeting of corporate members "to receive and deliberate upon the report of the council on the state of the institution, with the annual statement of the accounts, and to elect the council and officers for the ensuing year," took place on Tuesday, the 26th of May, Sir John Coode, K.C.M.G., the president, being in the chair.

In the report of the council for the session 1890-91, it was remarked that the salient feature of the session now terminated had been the realisation of a proposal made more than 40 years ago—namely, the formal reception by the president and council on stated evenings after the ordinary meetings of the members and visitors then present. This was proposed in 1850 by Sir William Cubitt, but for various reasons the suggestion was not acted upon, although, in a modified form, it was met by the *conversazione* given by the president. In progress of time the gradually increasing numbers forming the institution rendered the continuance of this social gathering impracticable. Sir William Cubitt's idea was—first, the provision, at intervals during the session, of an opportunity for the personal introduction to the president and council of those members who might not otherwise make their acquaintance; and secondly, the collection in the rooms of the institution of a limited number of models and specimens. A series of receptions was held after the ordinary meetings in the months of January, February, March, April, and May of this year. An endeavour has also been made to identify, in some degree, each gathering with a particular branch of engineering, both in respect to those invited to be present and to the models and other objects of interest exhibited. These receptions were believed to have been most successful, and experience would doubtless suggest directions in which they might be rendered still more useful and attractive in the future.

Passing to the usual business of the session, it was noted that 23 ordinary meetings were held, at which 11 papers had been read and discussed. For some of these papers Telford medals and Telford premiums had been awarded to Messrs. Ll. B. and C. W. Atkinson, and to Mr. R. E. B. Crompton, and Telford premiums to Messrs. F. E. Robertson, E. W. Stoney, Prof. John Milne and Mr. J. McDonald, Mr. W. Langdon and Mr. W. T. H. Carrington. For other papers, printed or to be printed in the *Proceedings* without being discussed, Telford premiums had been awarded to Messrs. B. Donkin, jun., J. J. Webster, and C. P. Sheibner. There were eight supplemental meetings for students, at which, unfortunately, the attendances had been small. For papers read at these meetings Miller prizes had been awarded to Messrs. E. L. Hill, J. H. Barker, W. A. P. Tait, B. Chatterton, J. W. Brown, A. Sealy-Allin, and W. H. Wheeler. The first three of these papers had been deemed worthy of publication, and would appear, either in whole or in part, in the *Minutes of Proceedings*. The works visited by the students were referred to as having been greatly appreciated by those who had availed themselves of the privileges offered, and the Council recorded its sense of indebtedness to the heads of the several establishments.

The effective increase in the roll of the institution during the past year was 247. There had been elected two honorary members, 51 members, 291 associate members, and seven associates, and three associate members had been restored to the register. Only 107 names had disappeared from the list. The number of members of all classes, students excepted, on March 31 last, was 5,150, as against 4,903 on the same day last year, representing an increase at the rate of 5 per cent. The student class had somewhat diminished in numbers, the total being, on March 31 last, at 914, as against 969 on the 31st of March, 1890. This was not due to any diminution in the numbers admitted, but to the fact that more students had been elected associate members during the year, and that a greater number had become ineligible to remain in the class by reason of having passed the limit of age—namely, 26 years. Adding the students to the number on the register, the gross total on the books was 6,064.

From the balance-sheet appended to the report, it appeared that the receipts during the financial year amounted to £24,274. 8s. 11d., and the payments to £23,351. 1s. 9d. The capital invested during the year represented the purchase of railway debenture stocks of the nominal (or par) value of £6,500, thus bringing up the institution investments to £50,000, besides which the corporation was possessed of freeholds which had cost £40,000, the Whitworth legacy of £5,400, and trust fund investments aggregating £15,286.

The council congratulated the members that, as a result of protracted litigation with the Inland Revenue Department, the House of Lords had upheld the judgment of the Court of Appeal, that the whole of the property of the institution was exempt from corporation duty under the Customs and Inland Revenue Act of 1885, on the ground that it was legally appropriated and applied for the promotion of education and science.

In conclusion, reference was made to the action of a committee of members outside the council, which had resulted in the establishment of an endowment fund for the purpose of perpetuating the memory of the long services of the secretary in the interests of the institution. It had been decided that the endowment in question, with any further additions, should be applied to the establishment of a "James Forrest Lectureship," it being left with the governing body for the time being to determine the subjects, the periods of recurrence, and all other details connected with such lectureship.

The adoption of the report was moved, seconded, and carried, and it was ordered to be printed in the *Minutes of Proceedings*. Cordial votes of thanks were then passed to the president, to the vice-presidents and other members of the council, to the auditors, to the secretaries and staff, and to the scrutineers.

The ballot for council resulted in the election of Mr. George Berkley as president; of Mr. H. Hayter, Mr. A. Giles, M.P., Sir Robert Rawlinson, K.C.B., and Sir Benjamin Baker, K.C.M.G., as vice-presidents; and of Mr. W. Anderson, D.C.L., Mr. J. Wolfe Barry, Mr. E. A. Cowper, Sir James N. Douglass, F.R.S., Sir Douglas Fox, Mr. J. Clarke Hawkshaw, M.A., Mr. Charles Hawksley, Sir Bradford Leslie, K.C.I.E., Mr. George Fosbery Lyster, Mr. J. Mansergh, Sir Guilford Molesworth, K.C.I.E., Mr. W. H. Preece, F.R.S., Sir E. J. Reed, K.C.B., F.R.S., M.P., Mr. W. Shelford, and Mr. F. W. Webb, as other members of the council.

BARNSLEY.

The Park and Lighting Committee, at the last meeting of the Council, had the following recommendation: "The committee recommend that in consequence of the withdrawal by the Westinghouse Electric Company of their tender, and of the withdrawal by the Board of Trade of their sanction to overhead wires, and of the large increase thereby occasioned in the cost of supplying electricity to the borough, the consideration of the present scheme be adjourned; and they further recommend that the borough surveyor be directed to prepare a scheme and plan for the supply of electricity to a smaller area, and to submit the same to the consideration of the committee as early as practicable."

Alderman Blackburn moved, and **Mr. Wheelhouse** seconded, the adoption of the minutes.

Mr. Sykes would like the chairman to give some better idea of the prospects the committee had in putting the Corporation to further expense in asking the surveyor to prepare plans for a smaller area. Unless they had better prospects than they had already he felt disposed, in the interests of the ratepayers, to oppose any other expenditure. He would prefer that the committee had made themselves to have said that having made all practical enquiries as to the advisability of further carrying on the project of electric lighting, they were prepared to propose it be adjourned until nearer the time of the expiration of the provisional order, that they might then have enquired what position they were in before dropping it. He had approved the enquiry into the cost of electric lighting when the gas company were charging more than they ought to pay, but he strongly objected to going to further expense unless they could give a better idea than they had. They had given the committee every chance, and he thought the matter ought to be postponed. If they were going to try a still smaller area the Council would set their backs up against it. He should object strongly, and believed the ratepayers would also strongly object to anything of the kind. He asked an explanation, and was prepared to move the matter be adjourned *sine die*.

Alderman Blackburn said the order expired in August of next year. When they found that the Board of Trade had withdrawn their consent to the overhead wires, the committee felt they would not be justified in asking the Council to continue in the scheme they had already adopted, because the extra cost would be so great. They did not intend to go to any further expense in the enquiry. The committee had felt very seriously the rebuffs of the Board of Trade, because that body had led the committee into the position in which they stood. If the Board of Trade had at first said they would not allow overhead wires, no one would have gone in for the extra expense. The cheapest way in which they could get it would be to give £33,000 instead of £23,000, as was at first intimated. Anybody who read the enquiry at Sheffield a week ago would see that electric lighting was practically snuffed out of the towns of this country. The refusal to allow the overhead wires meant that they could not go on with the electric lighting. The town clerk told them that there would be no difficulty in obtaining an extension of the time of the provisional order.

Mr. Raley asked further information as to cost.

Alderman Blackburn: It entails an extra expense of £500 per mile.

Mr. Wray: From £500 to £800 per mile.

Mr. Halton said the first estimate of the underground wires was £22,000 more than for the inner area.

Mr. Haigh: That was for the borough.

Mr. Tinker would like further information, as after all the noise that had been made he should not like this matter to end "like Cawthorne Feast, with a whew."

Mr. Sykes and **Mr. Tyas** approved the first part of the recommendation, but not the second.

Mr. Wray said the committee had done all that men could do, and only the Board of Trade was to blame for the position in which the matter stood. It would be ridiculous to ask the Council to give £1,400 or £1,500 per mile, making it from £600 to £1,000 per mile more than the cost of the overhead wires. It would be ridiculous to go to the outlying districts at such a cost. The committee could not help the action of the Board of Trade, nor the failure of the Westinghouse Company to carry out their contract. The Board of Trade had acknowledged that they had not treated the committee fairly. He should continue to make a noise in this matter so long as they were paying 30 per cent. more for their gas than Brighouse and other small towns. They did not wish to let this matter drop. They should like to ask that the borough surveyor map out an area which could be lit for £8,000 or £10,000, to light the business portion of the town, and he believed it could be made to pay. As to the question of cost, the only expense beyond that of obtaining the order was £50 to Mr. Bromley Holmes.

Mr. Woodcock believed the committee deserved every credit for having shown themselves believers in electric lighting. He was surprised that they should be such, and they could not bring the matter before them as they had done. He moved the confirmation of the minutes omitting the words after "adjourned."

Mr. Haigh explained that the idea of the new scheme was to supply only the business area of the town, which, he believed, could be done to pay.

Mr. J. H. Bailey supported the proposal of the committee, because it would keep any other company out of the town. They had been so well squeezed by the gas company, and ought never to allow another company to get into the town for lighting purposes. All the largest consumers were in the smaller area which had been indicated. There would be a large demand for the electric light in that area.

Mr. Wheelhouse submitted that in the centre of the town, where all the large consumers were, it would be possible to supply electricity to pay.

Mr. Sykes moved again an amendment that the words of the recommendation after "adjourned" be omitted.

Mr. Frith thought the committee ought to be allowed to go on.

The question was put, and Alderman Marsden and Councillors Woodcock, Sykes, Tinker, and Tyas voted for the amendment. The original motion was then carried.

LEGAL INTELLIGENCE.

MANGAN v. METROPOLITAN ELECTRIC SUPPLY COMPANY.

This action was brought in the Chancery Division of the Supreme Court, on Wednesday, before Lords Justices Lindley, Bowen, and Fry. The plaintiff claims an injunction to restrain the continuance of an alleged nuisance arising from noise produced by the working of electric machinery in Manchester-street, Manchester-square. The plaintiff also claims damages. The plaintiff applied for and obtained an interlocutory injunction to a limited extent, but a second application for an injunction was refused. The plaintiff afterwards applied by summons in Chambers for an order that the action should be transferred to the Queen's Bench Division and be tried with a special jury. On this summons Mr. Justice North made an order for transfer, and he refused a subsequent motion by the defendants to rescind the order. The defendants appealed.

Mr. Napier Higgins, Q.C., and Mr. J. G. Butcher were for the appellants.

The Court suggested that the best course would be to refer the action to an official referee for trial.

The defendants' counsel were willing to consent to this course, but Mr. Cozens-Hardy, Q.C., who (with Mr. Percy Gye) appeared for the plaintiff, declined to consent.

The Court dismissed the appeal, but reserved the question of the costs until after the trial.

Lord Justice Lindley said that in substance the Court was asked to order Mr. Justice North to try the action himself after he had come to the conclusion that it would be better tried with a jury. The action was an ordinary one for a nuisance, brought in the Chancery Division. By means of the two motions for an injunction the learned Judge had acquired a knowledge of the case. The plaintiff originally selected the Chancery Division, but he afterwards thought a jury would be a better tribunal for the trial than a judge alone. Mr. Justice North transferred the action to the Queen's Bench Division, in order that it might be tried with a jury. This Court was asked to set aside the order on the ground that the learned Judge, in exercising his discretion, had attached undue weight to the difficulty of assessing the damages. It was, however, obvious, from his judgment, that Mr. Justice North had not acted upon any general rule, but had fully considered the particular circumstances of the case. His Lordship did not think that this Court could differ from him, or that it ought to differ, unless it thought that his order would amount to a miscarriage of justice. The case of Jenkins *v.* Bushby, which had been relied on for the defendants, was a peculiar one. It was urged there that there would be a miscarriage of justice unless there could be a view of the property in question, and on this ground the Court of Appeal overruled the exercise of discretion by Mr. Justice Stirling, and ordered a trial with a jury. It was true that Rule 4 of Order 50 of the Rules of Court enabled a judge to have a view of the property himself, but in that case this would have been practically impossible by reason of the *locus in quo* from the railway station, and the Court of Appeal thought it essential for the purposes of justice that there should be a view of the property. There was nothing of that kind in the present case. The appeal would be dismissed, but the costs would be reserved until after the trial. If the Judge should come to the conclusion that the action ought to be referred, this might influence the Court in deciding how the costs ought to be borne.

Lord Justice Bowen and **Lord Justice Fry** concurred.

COMPANIES' MEETINGS.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY.

REPORT.

The Directors have pleasure in submitting to the shareholders the report and accounts of the operations of the Company for the year ending the 31st March, 1891, the latter showing a net profit of £11,573. 8s. 9d., which, with the amount carried forward from last year, leaves a balance of £13,416. 6s. 8d. for disposal, after making provision for doubtful debts. The Directors propose to deal with this amount as follows—viz., to pay a further dividend of 7 per cent. for the half-year on the ordinary shares, and 6 per cent. on the preference shares, making, with the interim dividend paid in November last, 6 per cent. for the year on both descriptions of shares; writing off the sum of £530. 3s. for depreciation of plant, machinery, and furniture, £63. 16s. 8d. from cost of new building, and the sum of £436 from goodwill and patent rights, thus leaving a balance of £1,716. 4s. 10d. to carry forward. The lawsuit in Belgium, relating to the patents in which the Edison Gower-Bell Telephone Company is interested, is still in the hands of the solicitors, but it is hoped that a decision will soon be arrived at. One of the patents for telephones held by the National Telephone Company expired on the 9th December last. This has had the effect of enabling the Consolidated Company to sell telephones to the public; and, so far as your Board can judge, an increasing business is in prospect. The shareholders may rely upon every effort being made to keep the Company's manufactures well in advance of both home and foreign competition. The subsidiary companies (the Telephone Company of Austria and the Anglo-Portuguese Telephone Company) continue to make most satisfactory progress, as is shown by the following statement for the year ending March 31st:

	Subscribers		Rental		Increase	
	1890.	1891.	1890.	1891.	Subs.	Rental
Austria	2,868	3,263	£18,100	£20,500	395	£2,400
Portuguese	1,915	2,074	£12,232	£13,458	159	£1,226
Total increase for the year					554	£3,626

In accordance with the articles of association, the following Directors retire by rotation, and being eligible, offer themselves for re-election—viz.: Sir Alexander Armstrong, K.C.B., etc., and Arthur Henry Baker, Esq. The auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and A. E. Green, Esq., F.S.A.A., also retire, and offer themselves for re-election.

The tenth ordinary meeting of this Company was held at the Cannon-street Hotel on Thursday, Mr. C. L. W. Fitz Gerald, chairman, presiding.

In moving the adoption of the report and balance-sheet, the **Chairman** said that the profits for the year amounted to £11,573. 8s. 9d., which, with the amount brought forward from last year, left a balance of £13,416. 6s. 8d. The Board proposed to pay a further dividend of 7 per cent. on the ordinary shares and 6 per cent. on the preference, which would make a dividend for the entire year of 6 per cent. in both classes of shares, writing off £535. 3s. for depreciation of plant and machinery, etc. The profit on manufacturing this year was less by £250 than last year. If they considered everything, he thought that was not at all bad. Wages had increased, coal had increased—in fact, pretty well all the materials they used had increased in cost, and yet they had only come out with £250 less. On the other side, they had received more in dividends from subsidiary companies and interest by the sum of £534, and that despite the fact that they had only received £50 from the River Plate investment instead of £250. Their expenses had risen a little (Auditors' fees, travelling expenses, etc.), amounting to a total of £135. When, however, he came to add up the entire expenses for the year he found that they had only spent £40 more than last year. He thought that might be considered very satisfactory. The plant and machinery was now valued at about £500—he thought it might be £530—less than it was last year. They had added some very fine new machinery to their plant, and he could safely say that it was never more efficient than at the present moment. He was now engaged with the officials in reorganising the plant to enable the Company to turn out more goods, as he had found that since the 9th December last, the date when one of the patents held by the National Telephone Company expired, there had been an increase in the business, and therefore he had to do something in the factory to enable them to keep pace with the times. Their stock was put down at £6,895. 16s. The stock, he was happy to say, had decreased since last year, which meant that they had not got so much of it on hand. To a certain extent it might be taken that the reason for that was because they had sold more of their manufactures complete, and not in parts. They would see from the balance-sheet that the Company were owed by the subsidiary companies and others a sum total of £8,993. 3s. 5d., and, on the other side, it would be seen that the Company only owed £1,669. 8s. 10d. He thought that was a very satisfactory feature of the report. As they were aware, the Board had not this year asked the shareholders for any money in the form of preference shares. The two previous years they had—in the first year for £15,000, and the second £10,000. They had added to their investments, both in the Anglo-Portuguese Telephone Company's debentures (10,900), and the Telephone Company of Austria preference shares. The Auditors had called the attention of the Board to the fact that some of the Company's securities had depreciated in value during the year. The Directors were of opinion that this depreciation might be only of a temporary nature. Should this view prove incorrect, however, it would no doubt be advisable to form a fund to meet that depreciation. The two securities were the National Telephone Company, and the River Plate Telephone Company of Buenos Ayres. As to the fact named, the depreciation was not owing to the business of the Company being bad, but to the difficulties of the Argentine Government, and the high premium on gold, which prevented the Company from remitting the money it earned. Surely that state of affairs would come right. As to the National Telephone Company, it was, to his certain knowledge, doing a bigger business than ever, and was going to pay dividends. The lawsuit in Belgium dragged on. He did not know whether they were any nearer a decision, but hoped so. The subsidiary companies were a gratifying item; they had gone on steadily increasing year by year in subscribers and revenue. Personally, he was very pleased with the balance-sheet, and, speaking for himself and the Board, he could say that they would try to do their best to make the Company go on satisfactorily and pay a bigger dividend.

The motion for the adoption of the report was seconded by **Sir Alexander Armstrong, K.C.B.**, and carried unanimously.

The retiring Directors (see report) and the Auditors having been re-elected,

Mr. J. H. Buckingham alluded to the formation of the Committee of Investigation in 1884, and the incidents arising out of it, particularly to the actions brought against the Directors. He then referred to the action brought against three of the old Board (who also sit on the present Board), Messrs. Fitzgerald, Grewing, and Baker, four years after the committee was appointed, and which was settled in 1890 without going into court. The reason (as the solicitor to the Company subsequently explained) being that it was thought inadvisable to make the affairs of the Company public after what had happened, and not that the above-named gentlemen would not go into court. They were most anxious to do so, in order to clear themselves, but were deterred from that course by their colleagues. He moved that remuneration not exceeding £600 be voted to them in consideration of the services rendered to the Company, and having regard to the expenses they were put to in connection with this lawsuit.

This was seconded by a **Shareholder**, and carried unanimously, remarks being made by more than one of the shareholders as to the value of the services rendered to the Company by Mr. Fitz-Gerald and his colleagues.

The **Chairman** having thanked those present, called attention to the instruments which had been fitted up in the room, for the shareholders' inspection, and which he hoped they would examine.

The proceedings then closed.

CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY.

The statutory meeting of this Company was held at Winchester House on Monday, the Lord Mayor (Mr. Alderman Savory) presiding.

The **Chairman** stated that the shareholders would be glad to hear that, notwithstanding the great financial depression and difficulty existing at the time, the Directors were enabled to launch the Company most satisfactorily, the capital being applied for nearly three times over. The object of the Company, with regard to which there had been some misconception, was not to take over provisional orders and contracts, but to initiate the supply of electricity by providing the contractors with funds, enabling the contractors, after they had obtained the concession from the Commissioners of Sewers, with the authority of the Board of Trade, to proceed with the work which they had undertaken, right being reserved to the Pioneer Company to launch at some future time a larger company to take over the concession which had been secured. In their early days they invited some of the leading electricians to meet the Directors, the object being to decide upon the best means and methods for lighting the City. The authorities whom they summoned were unanimously of opinion that the system which the Board had since adopted was the best suited for their requirements. They felt certain that when their work was completed the City of London would be second to no other city in the world in regard to the way in which it was lighted. The Company had secured most suitable sites for placing their machinery, that for the eastern district being near Tower-hill, and that for the central district at Bankside. The Directors had been doing a good deal of preparatory work in order to assist in every way possible the new company which it was proposed to establish at no distant period. The work was so far advanced that they hoped that Queen Victoria-street would be lighted by electricity about the middle of next month. They had taken the greatest possible care with regard to the smallest details. In reply to questions, the Chairman stated that if they called up more capital it would only be required for a very short time, because the new company to which he had referred would purchase what this Company had done, and the shareholders could either take shares in the new company or have their money returned. They thought the capital which they possessed was amply sufficient to carry on the works until the new company was established. Their one desire was to make the electric lighting of the City of London as perfect as it could possibly be made.

BIRMINGHAM ELECTRIC SUPPLY COMPANY.

The first annual meeting of this Company was held on Tuesday at the offices, Dale End, Birmingham, Mr. Henry Buckley presiding.

The report of the Directors was as follows: "The Directors are glad to be able to announce that the works of the supply station and the mains through a considerable portion of your area are complete and in working order. The works were formally opened by the Mayor (Mr. Alderman Clayton) on the 22nd of April, 1891. The demand for the light has been most satisfactory, and the works start on a system of 2,580 16-c.p. lamps. These lights are distributed amongst various offices and shops representing some of the most important professional and trade interests in the city, one of the first customers being the Corporation of Birmingham, with whom arrangements are made for the lighting of the Victoria Courts. In the purchase of the land and the laying out of the works and mains it has been necessary to provide for not only the present but for the future demand for the light—*i.e.*, the available land is sufficient for a station estimated to provide 25,000 16-c.p. lamps, and a chimney stack has been built large enough for this. The engine-house and boiler-shed will be sufficient for half this number, and for the immediate supply engines and boilers have been fixed for 5,000 lamps. Mains have now been laid through the most important streets within the Company's area, and current may be obtained along 7,000 yards of street frontages. The Company have been fortunate in securing a substantial tenant for a portion of the offices which will not at present be required."

In moving the adoption of the report, the **Chairman** said he had not a great deal to add to what he said at the recent opening of the Company's works. The orders were coming in very satisfactorily. Up to the present they had received orders for 2,639 lamps, but when they saw that such orders were spread over only 42 customers, it showed the shareholders what a good opening there was for the extension of their trade in the city. Bearing this in mind, the Directors had resolved to issue the balance of the shares in the first instance amongst the shareholders. This would enable them to cope with additions to plant that the extension of business will demand, and he was glad to inform them that, considering the broken holiday week, the shares had been well taken up. He thought he was justified in the statement that with the present year they would be able to pay the entire working expenses, and if that turned out as he expected, at the end of 1892 there was reasonable expectation that they would pay a dividend. But that must depend upon the earning power of the Company in Birmingham and the number of lamps applied for, and judging by the experience of other electric companies, he believed they would be making a profit from 1892. The report was adopted. The retiring directors (Mr. G. S. Albright and Mr. Buckley) were re-elected, and the auditors (Messrs. Sharp, Parsons, and Co.) were reoppointed.

INDO-EUROPEAN TELEGRAPH COMPANY.

At an extraordinary general meeting held on Monday the resolution passed at the meeting on the 28th ult., providing that the Managing Director should be a member of the Board, was unanimously confirmed.

COMPANIES' REPORTS.

NOTTING HILL ELECTRIC LIGHTING COMPANY.

Directors: William Crookes, Esq. F.R.S. (chairman); Arthur Ellis Franklin, Esq.; Alexander Howden, Esq.; James Thomas Jarvis, Esq.; Francis Ratford, Esq.; and Sidney Waters, Esq. Engineers: Messrs. J. E. Spagnoletti and Crookes; R. E. Crompton, Esq. (consulting). Auditors: Messrs. Deloitte, Dever, Griffiths, and Co.

Report of Directors and statement of accounts on the 31st December, 1890.

The Directors beg to submit herewith the accounts of the Company to the 31st December, 1890. It will be observed that the expenditure on capital account covers a period of nearly three years, from the 21st February, 1888 (the date of incorporation of the Company) to the 31st December, 1890. As, however, before the publication of the prospectus in January, 1890, no shares were issued beyond a few originally subscribed for and paid up in full by the founders of the Company, the bulk of the expenditure on the works has been incurred during a period of less than 12 months. On the 31st December, 1890, the capital paid up was £42,576, and the liability on the shares issued amounted to £27,444, and there remained £29,980 of unissued capital. Altogether 7,002 shares have been subscribed, and a special settlement was obtained on the Stock Exchange on July 1, 1890, for the 6,318 ordinary shares of £10 each, which were applied for and allotted in accordance with the prospectus, and an application has been lodged with the Stock Exchange Committee for a quotation of these shares upon the official list. The capital expenditure, as shown by the accounts, amounted at the end of the year to £43,126. 5s. 2d., but this sum does not include the further liabilities on contracts entered into for construction of buildings, mains, and machinery, since nearly completed. These amount to about £12,000, bringing the total of expenditure incurred and contracted for before the date of the opening of the works to about £55,500. Subsequent to the purchase of the lease of the property for a central station in Victoria-gardens, Notting Hill, which is referred to in the prospectus, the Directors took the opportunity which offered itself of acquiring the freehold. It also became necessary, owing to injunctions which were obtained during the construction of the central station by the owners of neighbouring property, to purchase the lease of seven small houses adjoining in Bulmer-place. These houses are all let. Considerable delay occurred in the completion of the works, owing, in the first place, to the injunctions above mentioned, and when the work could have been resumed the very severe weather supervened, thus making it impossible for the contractors to proceed for a considerable time with the building of the central station. The Directors are, however, glad to state that the central station has been now completed, and the Company is able to supply the electric current to houses situated in the principal streets of the northern and central portion of the area of supply, in which the mains have already been fixed.

The number of houses in the district which are prepared to take the light is continually increasing. Already the owners of 70 houses have notified their readiness to take the light. This number includes Holland House, and it is estimated that at the present time the installations comprise a total number of about 4,000 lamps reduced, as usual, to 8 c.p. The engineers have reason to believe that a considerable number of householders are intending to have their houses wired as soon as the current is actually being delivered, and it is expected that before next winter the generation of the amount of electrical current supplied to customers will profitably occupy the whole of the existing plant. Much difficulty has been experienced in obtaining a site for a second central station, but a provisional contract has now been entered into in reference to a site which the Directors consider well suited for the purpose, and as soon as the agreement is completed steps will be taken to lay the mains in the southern part of the district, when the whole of the parliamentary area granted to the Company can be supplied with the electric current. In this southern district an increase in the number of customers is to be expected in consequence of the decision of Lord Ilchester to let for building purposes about 2½ acres of Holland Park. The Directors who retire are Messrs. A. Howden and J. T. Jarvis, who, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., retire, and being eligible, offer themselves for re-election.

NOTTING HILL ELECTRIC LIGHTING COMPANY.—STATEMENT OF SHARE CAPITAL ON DECEMBER 31, 1890.

Description of capital authorised by memorandum and articles of association.	Number of shares issued.	Nominal amount of share.	Called up per share.	Total paid up.	Issued not paid up.	Remaining unissued.	Total amount authorised.
		£	£	£	£		£
£94,500, divided into 9,450 ordinary shares of £10 each	134 ordinary	10	10	1,340	25,272 ordinary	2,998 ordinary shares £29,980	94,500 ordinary shares
	6,318 ordinary	10	6	37,908			
	7 founders'	10	10	70	2,172 founders'		5,500 founders' shares
£5,500, divided into 550 founders' shares of £10 each	543 founders'	10	6	3,258			
£100,000	7,002 shares			£42,576	£27,444	£29,980	£100,000

CAPITAL ACCOUNT FROM THE 21ST FEBRUARY, 1888 (DATE OF INCORPORATION), TO THE 31ST DECEMBER, 1890.

Dr.			£ s. d.
Expenditure to 31st December, 1890—			
Lands and property, including law charges incidental to acquisition—Victoria-gardens—freehold		£5,515 0 0	
Bulmer-place—leasehold		1,875 0 0	
			7,390 0 0
Buildings			6,476 17 8
Fixed machinery			2,777 11 3
Accumulators at generating station			1,164 0 0
Mains, including the cost of laying and construction			18,347 15 10
Cost of license, provisional order, and total of all the preliminary expenses up to and including allotment			4,001 15 6
Local office (105, High-street, Notting Hill)—furniture and fittings			393 14 0
Law costs, including fees to defence associations and in connection with Bills in Parliament			539 3 8
Directors' fees, salaries of manager, secretary, clerks, and draughtsmen			1,446 17 0
Cost of opposing injunctions and compensation			435 0 0
General expenses—including rent, rates, taxes, printing, stationery, stamps, travelling expenses, carriage, insurance, and miscellaneous expenditure		£388 10 3	
Less—sundry receipts:			
Rents receivable	£118 19 1		
Transfer fees	4 2 6		
Interest on deposits	111 18 5		
		235 0 0	
			153 10 3
Total expenditure carried to balance-sheet			£43,126 5 2

Note.—Under existing contracts, relating to the construction of the mains and the equipment of the station, a further liability exists for unfinished work, amounting to £12,000 or thereabouts (without extras).

Cr.			£ s. d.
Capital receipts to 31st December, 1890—			
6,452 ordinary shares of £10 each	£64,520 0 0		
Less amount, uncalled—viz.: £4 per share on 6,318 shares	25,272 0 0		
		£39,248 0 0	
550 founders' shares of £10 each	5,500 0 0		
Less amount uncalled — viz: £4 per share on 543 shares	2,172 0 0		
		3,328 0 0	
			42,576 0 0
2,998 shares unissued.			
Total receipts carried to balance-sheet No. VIII.			42,576 0 0
Balance			550 5 2
			£43,126 5 2

General Balance-sheet at the 31st December, 1890.

Dr.				£	s.	d.
Capital account.—Amount received, as per account No. III.				42,576	0	0
Sundry trade and other creditors, on contracts for mains and machinery in course of construction, etc.				7,668	17	9
(For contingent liabilities see note on Form No. III.)						
				£50,244	17	9

Cr.				£	s.	d.
Capital account.—Amount expended for works, including preliminary expenses, as per account No. III.				43,126	5	2
Debtors for rent				31	7	9
Stock (movable plant and tools)				421	4	2
Cash at bankers—						
Messrs. Williams, Deacon, and Co., current account	£552	2	5			
Messrs. Williams, Deacon, and Co., deposit account	6,000	0	0			
Alliance Bank, Limited, Notting Hill	88	13	3			
Cash in hand	25	0	0			
				6,666	0	8
				£50,244	17	9

NEW COMPANIES REGISTERED.

Arc Accumulator Company, Limited.—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £1,000 in £1 shares. Object: to carry on in the United Kingdom the business of electricians, electrical engineers, etc. The regulations contained in Table A mainly apply.

Clegg's Metal Incandescent Lamp Company of France, Limited.—Registered by Bircham and Co., 46, Parliament-street, S.W., with a capital of £10,000 in £10 shares. Object: to carry into effect an agreement, made May 13, between James Clegg of the first part, Betts and Co., Limited, of the second part, and this Company of the third part, for the acquisition of certain inventions and patents relating to electric lamps and other electrical appliances, and to develop and work the same. There shall not be less than three nor more than eight Directors. The first are Archibald Campbell, Charles Cheswright, sen., James Clegg, Allan Maclean, Charles Cheswright, jun., Leveson Dudley Ryder, and Henry Tyler Cheswright. Qualification not specified. Remuneration: ordinary Directors, £350, divisible; Managing Director's remuneration to be determined in general meeting.

Woodfield Syndicate, Limited.—Registered by Maynard Carter, with a capital of £12,000 in £1 shares. Object: to carry on the business of an electrical engineer in all its branches in Great Britain, or any other part of the world. There shall not be less than two nor more than five Directors; the first are to be appointed by the subscribers to the memorandum of association. Qualification, being a shareholder. Remuneration to be determined in general meeting.

PROVISIONAL PATENTS, 1891.

May 19.

8499. **Improvements in apparatus for controlling electric currents.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

8540. **Improvements in conductors for electric railways.** Thomas James Moore and Edmond Augustus Warren, 6, Bream's-buildings, London. (Complete specification.)

8555. **Improvements in insulated electric conductors.** William Phillips Thompson, 6, Lord-street, Liverpool. (James B. Williams, United States.) (Complete specification.)

8573. **The manufacture and production of hydrocarbon products or compositions for use for insulating or other purposes.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (John Weir, United States.) (Complete specification.)

8575. **Improved methods of and apparatus for generating and utilising electric energy for lighting purposes.** Nikola Tesla, 45, Southampton-buildings, London. (Complete specification.)

8579. **An improvement relating to electrical belts, chiefly designed for medical purposes.** Cornelius Bennett Harness, 45, Southampton-buildings, London. (Complete specification.)

May 20.

8609. **Improved pipes or leads for electric conductors.** Thomas Smith, 186, Fleet-street, London.

8648. **Improvements connected with the use of compressed air for producing electric light and cold.** Ernest Bazin, 115, Cannon-street, London. (Complete specification.)

May 21.

8659. **Improvements in electric tramroads.** Arthur Hill Rowan, 65, Belvedere-road, Upper Norwood, London.

8664. **An improved storage cable.** Charles Sigmund, Knight of Ilanor, 52, Chancery-lane, London.

8680. **Improvements in or appertaining to the lighting of ships' signal lamps by electric light.** Charles Walter Cox, Frederick Robinson, and William Henry Gritton, 6, Lord-street, Liverpool.

8696. **Improvements in microphones.** Charles Huesler, Temple-chambers, London. (Caesar Vogt, Germany.)

May 22.

8622. **An improved form of carrier for shades and globes for gas and electric light.** Joseph Grace Smith Cunnington, Keats Cottage, John-street, Hampstead, London.

8735. **Improvements in electrical storage batteries or accumulators.** Edward Walter Berdoe and Godfrey Mason Shum, 11, Wellington-street, Strand, London.

8742. **Improvements in electrical organs or similar instruments.** Robert Hope-Jones, 6, Lord-street, Liverpool.

May 23.

8784. **Improved means of, and apparatus for, the transmission of telegraphic signals.** Sidney Evershed and Albert Edwin George Richards, 1, Queen Victoria-street, London.

8792. **Improvements in phonographs.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Béla Steiner, Hungary.)

8798. **Improvements in electrical signalling apparatus.** Ferdinand Hanusse and Georges Borrel, 323, High Holborn, London.

8806. **Improvements in dynamo-electric and electro-dynamic machines.** Alphonse Isidore Gravier, 191, Fleet-street, London.

8808. **Improvements in and relating to electrical batteries.** William John Green, 45, Southampton-buildings, London.

8811. **Improvements in and relating to electric meters.** Guglielmo Mengarini, 24, Southampton-buildings, London.

8812. **Improvements in or relating to casing and covers for electric wires.** Albert Hoster, 51, Cannon-street, London.

SPECIFICATIONS PUBLISHED.

1885.

15251. **Distributing electrical energy.** De Ferranti. (Third edition.) 8d.

1890.

8651. **Casing for electrical conductors, etc.** Smith. 6d.

9060. **Ships' telegraph.** Vialet-Chabrand. 1s. 1d.

10038. **Electrolytic treatment of metals.** Watt. 4d.

10276. **Electric search-lights.** Allison (Ward). 8d.

21043. **Telegraphic apparatus.** Essick. 11d.

1891.

1988. **Autographic telegraphs.** Imray (The Writing Telegraph Company). 8d.

2443. **Switch and signal apparatus.** Westinghouse and Schreuder. 2s.

3675. **Electrical currents.** Edwards (Kunhardt). 8d.

3839. **Electrotype blocks, etc.** Wolfe. 11d.

4715. **Electrically reproducing uneven, etc., surfaces.** Amstutz. 8d.

5548. **Insulated electric conductors.** Bishop. 6d.

5562. **Phonograph, etc.** Thompson (Dodge). 8d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for last week were £4,730.

Western Brazilian Telegraph Company.—The traffic receipts for last week were £3,803.

City and South London Railway.—The receipts for last week were £768, against £665 for the week ending May 16.

Paris-New York Cable Company.—At a recent meeting of this Company it was decided that an issue should be made of sufficient bonds to raise the capital to 12,000,000f.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	1¼
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9⅛
London Electric Supply	5	2½
Swan United	3½	4½
St. James'	—	6½
National Telephone	5	4¾
Electric Construction	10	7¼
Westminster Electric	—	4¾

NOTES.

Bristol Central Station.—The site for this station has been cleared and the foundations are being cut in.

Guildhall.—Preparations are now being made to lay the electric light on to the Guildhall offices and in the Chamberlain's department.

Heligoland.—The little island in the North Sea is having money lavishly spent upon it by the German Government. Amongst the items it is reported that £10,000 are to be expended upon a new cable.

Telephones in London.—It is stated that a combination of leading commercial men has been formed in London with the idea of putting pressure on the telephone companies for better and increased facilities. Not before it is time, either.

Telephones in Spain.—The Spanish Minister of the Interior has been authorised by the Government to plan and carry out an extended system of telephonic communication, for which purpose the country will be nominally divided into four zones.

Steam Trams.—The Board of Trade have refused to grant a renewal of the running powers of the North London Steam Tramways Company between Finsbury Park, Wood Green, and Edmonton. The steam cars will, therefore, on and after June 15, cease to run.

Civil Engineers.—At the first meeting of the newly-elected council of the Institution of Civil Engineers, the following officers were reappointed: Mr. H. L. Antrobus, as treasurer; Dr. Wm. Pole, F.R.S., honorary secretary, and Mr. James Forrest, the secretary.

Winding Up of the Edinburgh Exhibition.—The liquidator of the Edinburgh International Exhibition, 1890, is to pay a second dividend of 3s. in the pound in the end of June to the creditors of the exhibition. This will make 16s. 6d. paid on the total claims.

Cleckheaton.—The Cleckheaton Local Board are asking for tenders for lighting the Town Hall with electricity, according to specifications which may be seen at their offices. Tenders, suitably endorsed, are to be sent to Mr. J. Armitage, clerk, Cleckheaton, by June 9.

Explosion on Shipboard.—A fault in the electric light installation on board the s.s. "Tankerville" is suspected of having caused an explosion some weeks since. Mr. Sydney F. Walker has been in attendance at the Board of Trade enquiry into the circumstances to give evidence on this point.

Sule Skerry Lighthouse.—In the House of Commons on Monday, in reply to Mr. Lyell, Sir M. Hicks-Beach stated that the Board of Trade had given their statutory sanction to the erection of a first order group flashing-light on Sule Skerry, and it is expected that the work will be commenced this summer.

Rotherham.—At the Rotherham Town Council on Wednesday the question of the extension of the gas works was brought up, and Mr. Gummer proposed an amendment to the Gas Committee's report that the cost be ascertained of the erection of an electric installation. The amendment was, however, not accepted.

Liverpool and Toxteth.—The Bill to confirm the provisional orders granted by the Board of Trade to the Liverpool Electric Supply Company for the electric lighting of certain portions of Liverpool and Toxteth Park will, so far as those orders are concerned, pass unopposed through the House of Commons.

Electric Communication to Lighthouses.—At several shipping ports a movement has been set afoot in favour of electric communication being established with the principal lighthouses along the coast. The President of the Board of Trade has consented to receive a deputation on the subject from the Associated Chambers of Commerce on June 12.

Bishop's Stortford.—Tenders are invited for lighting the public streets, at present lighted, of the district of Bishop's Stortford, for one year from August 16, for the Local Board. Tenders must be on forms, which will be supplied by the Board, and are to be delivered to Mr. W. P. Slater, clerk, North-street, Bishop's Stortford, by 10 a.m. on 20th inst.

Electric Separator.—Mr. Chas. E. Hall, of Sheffield, has called attention to his patent, dated June 4th, 1881, for an electric separator in connection with grinding mills, as still the most promising of any yet devised. He states he has an important application of this principle in hand, but as his patent is still in force he draws attention of inventors to that fact.

South African Telegraphs.—The Eastern and South African Telegraph Company has received advice of the opening of a telegraph station at Fort Tuli, which is 600 miles north of Kimberley. The British South African Company has made arrangements to proceed without delay in continuing the line on to Fort Victoria, and thence to Fort Salisbury.

Electric Light on Snowdon.—A use has been found for Snowdon, lately purchased by Sir Edward Watkin. It is stated that a private châlet is built on the summit, and that Sir Edward is making arrangements for the occasional display there of a powerful electric light, which will be visible not only over a great part of Wales and England, but as far as Ireland also.

Post Office Telephonic Enterprise.—The postal authorities at Newcastle are now following in the wake of the enterprise of the period in the direction of telephonic communication. They have adopted the system of allowing anybody to speak from a call-office to a subscriber in Newcastle for a fee of 3d.; for 6d. one may talk to a subscriber in another town.

O.S.A. Paper.—Before the Old Students' Association at the Finsbury Technical College, on Wednesday, June 10, at 8 p.m., a paper will be read by Prof. Silvanus P. Thompson, D.Sc., on "Some Recent Developments in Optics." It needs no words of ours to assure our readers that the lecture will be extremely interesting, and we hope that there will be a large attendance of students and their friends.

Powerful Companies.—The following is from the *Times'* columns: "Electricity.—A powerful combination is in course of formation, privately, for the development of a lucrative department, the success of which has passed the experimental stage. The abuses of promotion avoided. Full particulars to *bonâ fide* investors. A seat at the board available to a man of means and business aptitude. Address, Electricity, etc."

Paddington.—A letter was read at the meeting of the Paddington Vestry last week from the Board of Trade, forwarding copy of letter addressed by them to the undertakers under electric lighting provisional orders, with reference to requests which they have made to be relieved from the obligation of keeping separate accounts of undertakings authorised by different provisional orders. This communication, which was a satisfactory one, was entered on the minutes.

The Tasmanian Exhibition.—The Tasmanian Exhibition Committee have advised the Agent-General in London that Mr. Pousty, electrical engineer, Launceston, is willing to act as agent for any English firm desiring to exhibit electrical apparatus in the Tasmanian Exhibition. The committee have every confidence in Mr. Pousty's ability as a practical electrician, and reference upon this point is permitted to Sir Edward Braddon, 5, Victoria-street, Westminster.

Munich.—Herr O. von Müller has laid before the Municipal Council of Munich a project for the electric lighting of the city. He proposes to obtain 2,200 h.p. for the purpose from turbines driven by water from the Isar. The number of lamps is to be 9,500, and the capital required is estimated at £155,000. The annual cost of running is put at £30,000, and a profit of £10,000 is estimated. The sanguine view is expressed that electricity will cost only two-fifths the price of gas.

Cricket Match.—Though one swallow doesn't make a summer, a cricket match evidently does. Summer is upon us, and the records of the achievements of rival electricians begin pouring in upon us. On Saturday a match was played between the renowned "Double Yoo Nahr" and the redoubtable "Eeceecee," at Walthamstow. The latter played two men short and gradually mounted to 83; the former, thanks to their own "Foley" and the "Long" hitting of another member, secured the victory with only five men in.

Excursions.—The Society of Architects announce their annual excursion this year to Belgium, *viâ* Ostend—to Bruges, Ghent, Brussels, Malines, and Antwerp for the first week, and Liège, Namur, Tournaye for the second, at a cost of £6 per week, leaving on August 22nd. Those wishing to take advantage of the arrangements and company might profitably do so. Possibly we may hear that our own Council of the Electrical Engineers will make arrangements for a Rhine tour, including Frankfort, for August.

The Keeley Motor.—A recent note informs us that Mr. Keeley, of motor fame, has severed his connection with the Keeley Motor Company, and claims to be investigating the laws of operation of the peculiar force. Very careful galvanometer tests, made by Prof. Kœnig on April 25th, showed that electricity or magnetism was not the propelling force, and rigid investigation did not disclose compressed air—"and yet it moved." Several professors of the Pennsylvania University, it appears, are still testing the wonderful motor.

Paris Companies.—The financiers of Berlin and Paris, not forgetting those of Frankfort, says the *Bulletin International*, are at this moment considerably preoccupied with the future of the electric lighting enterprises of Paris. The results have not come up to expectations, and in certain cases in the provinces, at Montpellier for example, arrangements, possibly definite, have been made to give up the concessions. The Parisian electric companies seem in a sufficiently precarious state not to load themselves with a heritage in which there is all to lose and nothing to be gained.

Starter and Brake for Tramways.—Mr. Huyzer, a Dutch engineer, has devised a system of starting tramcars combined with an effective brake that seems to have points of advantage. A lever is applied beneath the car in conjunction which start the car forward at the first impulse. The economy of power is given at $\frac{2}{3}$ per cent. This lever serves also as brake, the car being able to be stopped instantaneously on a decline. Tests made a few ays ago at Haarlem, on the works of the Beynes tramcar ks, are said to have succeeded perfectly, a completely loaded car being set in movement by the hand. The cost is given as £12 per car.

Telegraph Extension in Shetland.—The telegraph steamer "Monarch" arrived in Lerwick Harbour on Friday last from Westray, Orkney, and immediately commenced the work of laying a cable between Lerwick and the Island of Bressay, a distance of about one mile. The work was completed in the evening. The vessel afterwards proceeded to the Island of Whalsay, a large and important fishing district, which is also to be connected with the mainland by telegraph. The cable required there will be about eight miles long. Both these extensions are the outcome of recommendations by the Highland and Islands Commission.

Liverpool Corporation Electrical Laboratory.—At a meeting of the Watch Committee of the Liverpool Corporation on the 25th inst., the city engineer presented a list of candidates for the post of junior assistant to the electric inspector, Mr. Yeaman. Thirteen gentlemen had replied to the advertisement, and of these a short list of three had been compiled. The committee unanimously decided to appoint Mr. J. A. Robertson, of Peterborough, to the post. This gentleman is one of Prof. Jamieson's most successful students, and has had the advantage of a training in the laboratories of the Glasgow and West of Scotland Technical College.

Australia.—The Redfern (Australia) Council contemplate lighting Redfern by electricity, and the Williamson Electric and Engineering Company's tender for plant was selected as being most likely to fulfil the Council's requirements. The original tender from this firm was for the sum of £11,726. 17s., but owing to an intimation received from the Crown Solicitor to the effect that certain conditions would have to be complied with, the Council have had to add £480 to the price of the original tender. The sum of £750 has already been paid for the site. The scheme provides that the annual charge of working and maintaining the electric plant is to be £1,500, free of all other costs to the Council.

Scarborough and Whitby.—The Bill to confirm the provisional orders made by the Board of Trade have come before the Examiners of the House of Commons for proof of compliance with Standing Orders. Among them is one giving power to the mayor, aldermen, and burgesses of Scarborough for the electric lighting of the whole of Scarborough, with power to lay mains in Westborough, Newborough, St. Nicholas street, St. Nicholas Cliff, York-place, and the Crescent. There is also an order giving powers to the Whitby District Local Board for the supply of so much of the Local Government district of Whitby as lies to the westward of the River Esk and harbour of Whitby. Standing Orders in each case were found to have been complied with, and the Bills will therefore be allowed to go forward.

Killarney.—In the House of Commons on the 28th ult., on the order for the second reading of this Bill, relating to the town of Killarney, Mr. A. O'Connor moved its rejection, on the ground that the meeting of the Town Commissioners which approved of the scheme was not regularly summoned. Sir M. Hicks-Beach said that there would be a much greater demand for the electric light in Killarney than in an ordinary Irish country town. The real opposition to the Bill came, not from the inhabitants of the town, but from the gas company. He never before heard it suggested that the meeting of the Town Commissioners was irregularly summoned; but if any further enquiry were necessary a select committee was the proper tribunal to conduct such enquiry. The Bill was then read a second time.

Huddersfield Hotel Lighting.—The Imperial Hotel, Huddersfield, has been lighted with the electric light. The driving plant has been erected in a building at the rear of the hotel, about 80 16-cp. being installed. The effect when the premises are under illumination is extremely brilliant and pleasant. The dynamo employed is built by Messrs. Ernest Scott and Mountain, Limited, of Close Works, Newcastle-on-Tyne, and is of their newest type, capable of running 100 16-c p. incandescent lamps easily. The installation has been fitted up under the superintendence of Mr. E. G. Wimshurst, Messrs. Scott and Mountain's representative. The dynamo is driven at 180 revolutions a minute by a Stockport patent gas engine, indicating 19 h.p., made by Messrs. J. F. H. Andrew and Co., of Reddish, near Stockport.

Electrical Cranes.—The Allgemeine Company of Berlin are doing good business in the use of electric motors for elevators and cranes. For some time past the company has worked an electrical elevator for raising coal. A full load of a ton can be raised 30ft. in about 40 seconds. As the cage rises it automatically shuts the safety gates which the waggon had opened on its way down. The winding engine is automatically put out of gear when the cage reaches either end of its course. The waggon, on coming to the surface, is received by a powerful crane, which is put into connection with the current as soon as the winding engine stops. The waggon runs back by its own weight. The installation is provided with safety apparatus in the event of the breaking of the rope or of the pulley. The same company has had two travelling one-ton cranes at work for some time.

Telephone Rates in Paris.—A rather peculiar discussion has been brought about in Paris with reference to telephone rates. The old subscribers paid 600f. a year, the new ones now pay 400f. and the cost of their apparatus. The old subscribers have been also reduced to 400f., but now it seems to have been felt by the authorities, after much deliberation, that these latter have had the better bargain, and a notice has been sent inviting them to defray the expenses of their instruments, like the new comers. In the Chamber a strong question was asked, and in reply M. Jules Roche explained that the invitation intended no attempt at coercion, and must be regarded simply as a "notice." The authorities must have been singularly guileless to expect such an invitation to take effect, and the proper sense of the effect of the explanation seems to have been gauged by M. Floquet, who remarked that this declaration made the notice null and void.

Magdeburg Electrical Testing Station.—At Magdeburg the electrical testing establishment, which has been in operation for nearly a year, has continued to be fully employed up to the present time. Like the association for the inspection of boilers, it undertakes to make for its members yearly inspections of electrical installations. In this way it has accomplished very useful work for the owners of electrical works. Its influence has been the more powerful in consequence of the fact that it is entirely independent of electrical firms, and can therefore give an unbiassed opinion. The activity of this establishment, remarks *Industries*, is felt throughout the whole of Germany. Its works consists in examining and reporting on the estimates for electrical installations. It affords advice and information concerning electrical apparatus, and gives its members by means of circulars the benefits of the experience which it has gained in carrying out the inspections.

Hull.—A meeting of the Electric Lighting Committee of the Hull Corporation was held at the Town Hall on Wednesday. The minutes of the sub-committee appointed to obtain information with regard to the best system of electric lighting recommended that an installation be laid down by the Corporation, such system to consist of a low-tension continuous-current system, as at Bradford and London; that the boilers be of the locomotive or the Lancashire type; engines of the Willans type, as at Bradford; dynamos of the latest type of Messrs. Siemens's low-pressure continuous-current; and that the mains be laid in culverts on the three-wire system, uninsulated. The minutes were discussed at considerable length, and on the motion of the chairman, seconded by Mr. Massey, it was resolved by a large majority to recommend the Council to empower the committee to at once take the necessary steps for laying down such an installation as might be desirable on the lines of the sub-committee's report, at a cost not exceeding £22,000.

Exeter.—The Bill to confirm the provisional order granted by the Board of Trade to the Exeter Electric Light Company will pass unopposed through the House of Commons, no petition having been lodged in opposition within the time limited by the Standing Orders. Under this order, which contains 82 clauses, the company's area of supply is limited to "the whole of the city and county of the city of Exeter," but the company is placed under an obligation to lay distributing mains within a period of two years after the order has come into force, along certain principal streets. In the event of the company failing to lay down mains along these streets within the limited time, the Board of Trade take permissive power to revoke the whole or any portion of the order. As regards the remaining streets within the area of supply, the company is compelled at any time after the expiration of 18 months from the commencement of the order to lay down distributing mains in any such street within six months, upon a requisition to do so signed by six or more owners or occupiers of premises. This order will come into force immediately upon the Confirmation Bill receiving the Royal assent.

Switzerland.—Efforts are being made in the Alpine countries to use the masses of water which rush wildly down the mountain sides as a means of producing electricity. Turbines placed at the foot of the falls are turned by the force of the water, and a dynamo is attached to the turbine and driven by belting. In this way no fewer than 12 towns in Switzerland, says the *Daily News*, are fixing up electrical apparatus for lighting and power purposes. In places where falling water abounds electricity can be made cheaply. As an illustration it may be mentioned that a very curious electric company has been formed at the village Faide, on the Gothard Railway, a place numbering 1,000 inhabitants. By means of an iron pipe a small supply of water is obtained from the neighbouring Pinmogna torrent, which drives below a small high-pressure turbine, which in turn drives a dynamo supplying 360 glow lamps. The whole cost under £2,000, which sum is divided into shares of £15, the owners forming the company. In this manner, in addition to the streets and railway station, the peasants and working men have their houses supplied very cheaply with the electric light, which is elsewhere regarded as a luxury.

Cardiff.—The Bill to confirm the provisional order granted by the Board of Trade to the Corporation of Cardiff for the electric lighting of the borough will, so far as that order is concerned, pass unopposed through the House of Commons, no petition having been lodged in opposition within the time limited by the Standing Orders. Under this order, which contains 72 clauses, the Corporation's area of supply is limited to "the whole of the county and municipal borough of Cardiff"; but the Corporation are placed under an obligation to lay distributing mains within a period of two years after the order has come into force along certain streets. In the event of the Corporation failing to lay down mains along these streets within the time named, the Board of Trade take permissive power to revoke the whole or any portion of the order. As regards the remaining streets within the area of supply, the Corporation are compelled at any time after the expiration of 18 months from the commencement of the order to lay down distributing mains in any street within six months, upon being requested to do so, by requisition signed by six or more owners or occupiers of property. The order will come into operation immediately upon the Bill receiving the Royal assent.

Austrian Imperial Train.—The Emperor Francis Joseph inspected at Vienna, on Tuesday, a handsome special train built for his express use, the cost of which is 100,000 florins. The train has eight cars, five with eight wheels each and three with six wheels. The service car comes immediately after the engine. It has a compartment for the baggage, and dynamos for producing the electric light. The second car is for the Emperor's servants, and the third is the Imperial car proper. It has handsome plate-glass windows, and bears the eagle and crown, but is not otherwise adorned. It comprises a special room for the aide-de-camp, a sitting and a bedroom for the Emperor, a toilet-room with a bath, and a small room for the Emperor's henchman. The Emperor's apartments are beautifully panelled. The other cars are for suite, kitchen, and baggage. All are lighted by electric light. The Emperor was very much pleased with the train, which is a present to him from the administrations of all the Austrian railways. It was built in Prague. Up to the present the Emperor had no special train belonging to him, and each railway line had to put an Imperial train together as best it could. With this new special train the Emperor will travel on all lines.

Finchley.—A special meeting was held last week by the Finchley Local Board to consider the report of the Lighting Committee, and to pass a resolution to apply to the Board of Trade for a provisional order. The House-to-House Company has proposed to supply electricity within the districts of Hampstead, Finchley, Hendon, and Willesden, but objections were made by the Finchley Local Board, and the order, so far at least as regards Finchley, was dropped. The committee recommend the Board to apply themselves for an order. Mr. Francis Smythe presented an elaborate report, giving a large amount of information as to methods of lighting, to the Board, and estimating that plant for the 408 lamps needed of 32 c.p., would cost £14,000, including three 60-h.p. engines, one in reserve; annual expense £1,251, costing £3. 1s. 4d. per electric lamp, instead of £2. 0s. 6d. as now for gas, it being remembered that the difference of light was greatly in favour of the electric light. The cost for providing an installation of 3,000 8-c.p. lamps for private lighting and the 408 32-c.p. lamps, as before, is estimated at £19,000, including four 100-h.p. engines; annual expense £2,500, while the estimated revenue is given as £2,000, leaving £500 as the cost of public lighting. The resolution authorising the Board to apply to the Board of Trade for the provisional order was carried.

Romford.—Tenders were received and discussed at the Romford Local Board from the Romford Gas Company and the Aurora Electric Lighting and Distribution Company, of 54, New Broad-street, E.C., for lighting the public streets from August 10 next to June 10, 1892. The gas company offered to light the town at £3. 6s. per lamp for that period; and for £4 per lamp for 12 months, from September 1 The electric lighting company offered to light with 16-c.p. incandescent lamps, from sunset to sunrise, from August to June, for £2. 17s. per lamp, including cost of cleaning and repairing; and for the 12 months at £3 per lamp. For lamps of 50 c.p., for 10 and 12 months, the cost would be £4. 5s. and £4. 10s. respectively, including the cost of Edison-Swan lamps, which might be placed on ordinary gas standards. For lighting with arc lamps of from 100 c.p. to 150 c.p. for the different periods, the cost would be £14. 6s. 6d. and £15. 19s. per lamp respectively, in addition to the cost of lamps and standards. As to the electric lighting, Mr. Dowsing said he knew of a smaller town than Romford that was going in for electric lighting; but the chairman said he did not think the Board would be justified in handing the town over to the electric lighting company. Mr. Westgate did not see why they should not give the electric system a trial and see which was best. The tender of the gas company was accepted.

Paper Insulated Cables.—Mains to the extent of a mile a day are now being made by a company entitled the Norwich Insulated Wire Company, of New York, in which paper (the material with which the Ferranti mains are insulated) is used as insulation. The process of manufacture is simple, but requires care and watchfulness. The paper is made expressly, and require storing for seasoning like wood. It is made in rolls of a mile or so, weighing 20lb. to 90lb. a ream. It is cut into strips by circular shears, mounted on mandrels to fit the covering machines, which, revolving at from 60 to 500 turns a minute according to size, overlap the conductor in spirals. With every spiral the cable is compressed, the spirals being laid on in opposite directions. It is heated to 250deg. to expel moisture, and plunged in insulating compound at 270deg. for a certain length of time. It is then passed through hydraulic presses and overlaid with lead. The cables are tested at 2,500 volts. The insulation is always high, exceeding 2,000 megohms at 75deg. F. Some of the tests are remarkable. Lengths of 1,000ft. were submitted to one of the large electric light companies, with request to "break down." Up to 10,000 volts was put in, and the cable was then returned intact. The cable was then boiled in water for 48 hours, and then resisted a potential of nearly 8,000 volts before failing.

Telephones in Yorkshire.—We alluded last week to the action taken in amalgamating the Leeds telephone exchange to the Mutual. It may be well to give the words of Mr. Zossenheim before the monthly meeting of the Leeds Chamber of Commerce on this subject, in which he gave expression to the widespread feeling that existed in this country, that we are far behind other countries in our telephonic facilities. Mr. Zossenheim remarked that he knew the Chamber had been much interested, as had trade generally throughout Yorkshire, in the matter of telephonic communication. With regard to the telephone, he thought he might say, without fear of contradiction, that in this country we were far behind any part of Europe in our mode of communication and in the cheapness of the supply. He knew that at Hamburg and other places abroad the telephone was within the reach of every private house. He had been to Manchester to inspect the new Mutual system in operation there, and the communication seemed to him, so far as his own experience went, perfect. He could hear everything. He also saw testimonials from leading merchants in Manchester, who stated that they were very well satisfied with the communication. He thought it would be a great boon if this new system was introduced into Yorkshire. As he understood, it would be entirely on the Mutual system, the charges would be moderate, and the shares would carry up to 10 per cent. interest, anything beyond that going to a reduction of the rates. In Manchester they had succeeded in amalgamating the Telephone Exchange Company with the Mutual, and the system would be carried throughout Lancashire, Yorkshire, and Cheshire.

The Royal Naval Exhibition.—A new spectacle was presented to the visitors at the Royal Naval Exhibition on Monday night, illustrating an attack upon and the defence of a harbour, in the course of which the electric search-lights were turned upon the lake, so that the movements of the warships and torpedo boats were plainly visible, though the night was dark. The movements of the diver who walked along the bottom of the lake carrying an electric lamp were distinctly followed by the spectators, and the whole concluded with several startling explosions on the surface, as well as below the water. In our account of the exhibition last week we should have given some notice to the "artificial iceberg," which is one of the features of attraction, exhibiting, as it does in the room inside, some striking and realistic effects of a Polar exhibition on the ice floes. The electric lighting of this scene has been carried out by Messrs. E. L. Berry, Harrison, and Co., of Lyric-chambers, Whitcomb-street, who have introduced a number of quite novel effects, especially a representation of the aurora borealis, flashing of the northern lights, and by a new combination numerous changes of the season during the Arctic year. These effects were specially honoured, we are informed, by the Queen's special approval on the occasion of the Royal visit of the 7th of May last. At the back of the iceberg, the firm mentioned have a space in which they are exhibiting various fittings both as applied to ship and house lighting, a motor and blower combined for force draught and ventilation, and especially a new arc lamp, for which they claim perfect steadiness and focus of light, and moderate price. They also intend showing a new and effective dynamo. The shooting gallery of "Crusoe's Island" is also fitted by the same firm with incandescent lamps and their new arc lamp.

Leeds.—The Bill to confirm the provisional order granted by the Board of Trade to the Yorkshire House-to-House Electricity Company for the electric lighting of Leeds will, so far as that order is concerned, pass unopposed through the House of Commons, no petition having been lodged in opposition within the time limited by the Standing Orders. Under this order, which contains 82 clauses, the company's area of supply is limited to "the whole of the municipal borough of Leeds," and the capital of the company is exclusively allocated to the supply of electricity within this area. The company is also placed under an obligation to lay distributing mains, within a period of two years after the order has come into force, along the following streets—viz., Briggate, New Briggate, Kirkgate (from Briggate to Vicar-lane), Boar-lane, Wellington-street (from Boar-lane to the Central railway station), Infirmary-street, King-street, York-place, Park-square, St. Paul's-street (from King-street to Queen-street), Park-lane, East-parade, Bond-street, Commercial-street, Park-row, Cookridge-street, Albion-street, Land's-lane, Upperhead-row, Woodhouse-lane, and Headingley-lane. In the event of the company failing to lay down mains along these streets within the limited time, the Board of Trade take permissive power to revoke the whole or any portion of this order. As regards the remaining streets within the area of supply, the company is compelled, at any time after the expiration of 18 months from the commencement of the order, to lay down distributing mains in any such street within six months upon being requested by requisition to do so, signed by one or more owners or occupiers of premises, or the authority having the control of the public lamps. This order will come into force immediately upon the Confirmation Bill receiving the Royal assent.

Electrical Safety Apparatus for Cages.—Before the Federated Institution of Mining Engineers, in the rooms of the Institution of Civil Engineers, Mr. John Yates read a paper on "An Electrical Safety Apparatus for Cages." He said that although great advances had been made in recent years in nearly every branch of mine engineering, engineers were no better off to-day for a reliable safety cage than they were 20 years ago. They had either been unable to devise a good safety apparatus, or had not given that attention to the matter which it deserved. That it deserved attention could not be doubted in the face of the statistics contained in the report of Her Majesty's Inspectors of Mines. According to these reports there were between the years 1880-1890 no less than 45 fatal accidents, resulting in 87 deaths, caused by the breaking of ropes and chains in shafts. Experience had shown that an apparatus which acted indirectly through the medium of a spring or otherwise was not to be relied upon. What was wanted was an apparatus which would require nothing more to bring it into action than the breaking of the rope, and which would be entirely independent of everything but that. For some time past he had been at work on the matter, and the result of his labours had been the invention of an apparatus which appeared to promise safety in case of breakage of rope. The principle of his invention was to use the hauling rope as the means for conveying a current of electricity to four electromagnets with the cage, each of the magnets sustaining a gripping cam. On the fracture of the rope and the breaking of the current, the cams would drop into play against the guides. After a short discussion, the author of the paper was thanked for his contribution.

Thermo-Electric Stove.—The simultaneous heating and lighting of a room is the object of the thermo-electric stove designed by M. Giraud. The products of combustion escape through a vertical tube, and redescend through a chamber concentric to this before issuing from the chimney. This disposition equalises the interior temperature. The hot gases come into contact with a series of rectangular boxes of sheet iron, forming a kind of honeycomb arrangement in which the thermo-electric elements are placed. These elements, to the number of about 700, are arranged in horizontal circular sets. They are formed of couples of nickel or tin, and an alloy with a base of zinc and antimony, to which are added small quantities of certain other metals, with the object of adding to the mechanical strength and retarding fusion. The elements in the sheet-iron cells are insulated by a wrapping of asbestos. The cooling is produced partly by wings or radiators and partly by the circulation of air arranged between the elements. The 700 elements are all connected in series, and give practically the same maximum useful power whether in nickel or tin. The E.M.F. is about 40 volts in full working, and the current on short circuit is four amperes. Under the conditions of maximum useful effect (the only conditions in which thermopiles need be considered, as the consumption of fuel is independent of the effect of the battery), the useful output is 40 watts, corresponding to about one kilowatt-hour per day continuous working. The consumption of coke is 62lb. per day. The cost of this is given as 1½f. for the kilowatt-hour, a price almost exactly the same as the maximum charged by the Paris electric light stations. As the current is too small to light more than one lamp at a time, it is necessary to get the best effect to use accumulators, which increases the first cost and reduces the quantity of electric energy at disposal.

OPENING OF THE NOTTING HILL ELECTRIC LIGHT STATION.

Quite a large and fashionable assembly was gathered in the new electric central station of the Notting Hill Electric Supply Company last Saturday afternoon, on the occasion of the formal opening of the station for public supply. Several well-known scientific men were present, and the large and open accumulator-room was simply crowded with Notting Hill residents, their wives and daughters, met together to hear the opening speech of the gifted chairman, Mr. William Crookes, F.R.S., and to view the machinery which is to light their houses with electric light. The electric light station is along a narrow court, named Bulmer-place, just opposite the Notting Hill Gate underground railway station. The rooms were swept clean, and decorated with a handsome array of flowers and incandescent lamps bearing a design of

N. H. E. L. C.
1891.

presently to be illuminated by the current, while the extensive side table, covered with tea urns, decanters, fruit, and cakes gave quite a festive air to the occasion.

Mr. WILLIAM CROOKES, as chairman of the company, in inaugurating the station, said: The meeting of that day was the realisation of that which had been his dream for a great many years. He had been connected with electric lighting for he knew not how long. His own house had been lighted for about 10 years, and it was from the interest taken in that light by some of his friends, and particularly by Mr. Waters, that was due the existence of the present company, which had been carried out energetically until the result was seen in the very fine works in which they were. He was aware that others had early adopted the light privately in their houses, but he thought he was safe in saying that his was the first house in England that had been lighted by the electric light. Curiously, an extraordinary report was put about the neighbourhood at that time during the excavation in his cellar. The word "dynamo" was not so well known then as it was now, though "dynamite" was known by the men, and the report got about that he was establishing a dynamite factory in his house! Happily, that state of mind has now passed away, and electric light is now almost as common in houses in London as gas or as candles. There were in the engine-room below three dynamos—one of 350 h.p., and two others of 70 h.p.—coupled direct to the engines. The system will be capable of supplying 12,000 lamps, and by adding a subsidiary station at Phillimore-mews (which they may do before many months), 6,000 more lamps will be able to be lighted, and filling up the space left with other machinery he believed they would be able to supply houses containing a total of 50,000 lamps, with their dynamos and the two sets of accumulators they saw behind them. For regulation they had the large and complete switchboard downstairs, which he hoped they would inspect. Electricity is distributed from their station by what is known as the three-wire system, by which a considerable amount of the copper mains, otherwise necessary, is saved—cost of copper being the great expense in electric light systems. In the building of the station they had removed 10,000 loads of earth, had used 1,450 tons of material, had laid together 700,000 bricks; they had built three miles of culverts under the streets, and had laid five miles of cable for distributing the current, or a total of 14 miles of conductor weighing 67 tons of copper. Houses have been wired for 5,000 8-c.p. lamps. Not a single fault or leakage has been found in the mains. They have been under test for the last two or three weeks, and several houses have been experimentally lighted. This told well for the completeness and safety of their system and the ability of their engineers. He would like, while speaking of the engineers, to introduce one very important member of the staff who was rather bashful, and would have to be brought forward—the little dog who had been trained to run along the culvert, carrying the rope in his mouth by which the copper mains were drawn into the culverts. He thought he deserved a vote of thanks. [The dog was brought in and doggishly wriggled his acknowledgments, and was speedily made a great pet of by the ladies.] Electricity, Mr. Crookes went on to say, in this age of competition was made, as other things were apt to be, of very different qualities. There are several kinds of electricity supplied to the people of London — and "ours is the very best!" That of the bad quality is the 10,000-volt electricity, which would be sudden death to touch. That used at Notting Hill is low tension, which, as could be seen by the bare mains in front of them, would not hurt the bare hands of any person, even a little child. He had, he said, some idea of bringing a sample of the high pressure to show them the difference, but desisted, as he was afraid they might have an accident. The difference in pressure was analogous to the different pressures in water mains; they could either have large and slow current, or small pipes and very forcible current. In the high-pressure electricity there must always exist the danger of leakage, and of the insulation giving way, dangers which were absent in their own system. In the system there was nothing exceeding 100 volts sent into the houses, a pressure which was perfectly safe and harmless. During the whole time they had been erecting the station and laying the mains they had had no accidents, or rather they had one—that of a gentlemen (he must have been dining) who had his hat knocked against one of the underground mains! He brought a claim against them, and they supplied him with a new Lincoln and Bennett. There is only one complaint about the light, and this is that the gentlemen cannot light a cigar or cigarette by it, and even this will be remedied before long. Is it cheaper than gas? was the question most of the intending customers would be asking, added Mr. Crookes. Well, it is dearer and it is cheaper: light for light it is not cheaper—it is two and a half times dearer than gas; but it is much cheaper than gas if incidental savings are taken into consideration. Electric light does not destroy and blacken the decorations and painted work in our houses; the gilding remains fresh; the binding of books is not destroyed; fittings are not attacked and injured by the sulphur which is always given off by gas lights; added to this, the air people breathe is kept pure, and cool, and fresh, and if proper precautions are taken, the fire risk (which arises mostly from open lights or dropped matches) is almost entirely annihilated. Another reason which tends to make the electric light cheaper than would appear is that the switches can be placed just inside the room, and when the room is left the light can be turned off, while gas would be usually left on because of the trouble of lighting it again. [The chairman then asked Mrs. Crookes to turn on the light, which blazed up in the illuminated design and bouquets on the table.] Shakespeare, he went on to say, pointing to the brilliant lights, was, unfortunately, not acquainted with the beauties of the electric light; but one might almost fancy he had been from some lines in "Julius Cæsar," which certainly applied to what they saw before them:

> "And with unnumber'd sparks they are all fire,
> And every one doth shine."

He wished them, while looking at those points of fire, to notice the example of the correlation of the forces that was illustrated by the light before them. Millions of years ago the sun shone on the earth; plants grew, they died, and in course of time were converted into coal; that coal has been dug up, and had been giving out its heat into the boilers downstairs; the heat of the coal had been raising steam; the steam had put the steam engine in motion, and this mechanical motion had been converted by the aid of modern machinery into the molecular force of magnetism; that magnetism had reacted upon the dynamo and had produced a current of electricity; this current had been led to the battery, and there converted into chemical action, and this had been again changed into electrical energy, which passes into the lamps, where it is converted into heat and into light, and this electric light is the identical solar energy which shone on the earth those thousands or millions of years ago.

A vote of thanks was enthusiastically passed to Mr. Crookes for his interesting speech, and to Mrs. Crookes for turning on the light, and also to the engineers, including the dog, for their exertions in bringing the installation to such a satisfactory result. The visitors then dispersed to inspect the machinery.

THE STATION.

The engine and dynamo room of the Notting Hill electric station lies some 40ft. below the ground level, and is a spacious and lofty room, supported by cast-iron pillars, and with room for considerable extension. The acting engineer for the company is Mr. J. Crookes, of Messrs. Spagnoletti and Crookes; Mr Crompton is the consulting engineer, and Mr. Schultz the resident engineer. The work has been designed by J. Mr. Crookes, in collaboration with Mr. Crompton, and all the contracts have been given direct to the various firms whose special manufactures are used, without further charge than a small percentage to the engineer, such as is usual to an architect. Mr. Fox is the energetic secretary, and Mr. Slater the architect to the company.

The station is on the three-wire low-pressure system, with Willans engines and Crompton dynamos with Crompton-Howell accumulators. There are three sets of engines and dynamos at present erected—one large "I I" Willans engine driving a Crompton dynamo giving 500 amperes and 240 volts at 350 revolutions. This machine has been tested for a six hours' run on full load, and ran so cool that it was not necessary by the engineer even to take its temperature. There are two other smaller dynamos driven by "G G" Willans engines, and yielding 500 amperes at 110 to 115 volts. Two large Babcock and Wilcox boilers, of 360 h.p. each, supply steam, and besides these there are two smaller Marshall locomotive boilers, of 70 h.p. each, for driving the smaller engines alone when needed. The two steam-pipes of each boiler are connected together by steam drums, each again connected by means of valves and steam-pipes to an extremely strong boiler drum made of boiler plates. All the pipes are connected, so that any boiler and any engine can be cut out or run separately as desired. There is room for three more Babcock and Wilcox boilers, and five more "I I" engines and dynamos. Copper steam-pipes are not used, all steam being carried in wrought-iron pipes fitted with expansion pieces. The feed-water is supplied by a pair of Worthington steam pumps, and a Babcock and Wilcox water heater utilises the heat of the exhaust steam, which exhausts into a large tank, and drains into a sump, from whence it is pumped above the level of the street drains by a pulsometer. This sump has a float and an electric contact to notify when the waste water gets beyond a certain level. The exhausts are coupled between each engine, and the pipes pass under the floor in special conduits.

The station is also fitted with an eight-ton travelling crane, which enables the erecting of the machinery to be easily accomplished.

One side of the station is fitted with the elaborate accumulator and dynamo switchboard first designed by Mr. Crompton for his Kensington Court station. This allows the dynamos to be coupled either on the mains or on the batteries, and the batteries to be regulated to keep the feeders always at their proper voltage. Any feeder can be also disconnected as required.

The dynamos at present are only run about four hours every day, the current being supplied night and day from the accumulators. The smaller dynamos can be switched on to either side of the three-wire system as desired, if heavy current is being taken for balls at the houses of customers or other occasions, but the mains are never charged direct alone from the dynamos. About 4,000 lamps in the houses are now wired and connected to the mains, and houses are being added by three or four a day. Not more than 30 per cent. of the lamps wired are found to be lighted at the same time. Aron meters are used both on the station and in the customers' houses. Other types of meters are also being carefully tested by the electricians.

The station comprises a large coal store, in which some 120 tons of coal can be stored. The quality of coal burnt is good, costing about 22s. a ton. Tests have been carefully made of the economy of the engine and dynamos. Mr. Crompton gives the following figures: Coal burnt in actual production of current, 3·5lb. per unit, or 2·4lb. per electrical horse-power per hour of 10 hours run, measured; the boilers using 9lb. of coal per horse-power hour, this gives 22lb. of water evaporated per electrical horse-power hour; the combined efficiency of engine and boiler from steam to electric current is 85 to 86 per cent.

The staff comprises a resident engineer, an engine driver, a stoker, a coal trimmer, a leading fitter, a switchman; this staff would be sufficient for the station supplying 15,000 lamps. The station has its own little repairing and fitting shop, with screwing machines, lathe, and drilling machine.

The mains in the station are bare copper rods run along the roof in air, insulated by Crompton glass insulators. The mains are all painted red (positive), black (negative), and the centre mains are indicated by alternate red and black, or by grey paint.

The battery consists of two sets of 56 cells, 112 cells in all, of large size Crompton-Howell accumulators. There are 68 plates in each, and they are capable of large and quick discharge—at need, 500 amperes for one hour. They have acted very well, only four plates being found to buckle in the slightest in getting to work. They are tested every morning for voltage and specific gravity.

The street mains are on the Crompton system, which we have lately fully illustrated—bare copper strips stretched in air in underground culverts and insulated at distances of 40 to 100 yards by glass insulators.

Another station will be erected at Addison-road, and a sub-battery station is to be established on the Phillimore Estate, near Phillimore-gardens.

TESLA'S EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH FREQUENCY.

We have received the following advance abstract from the New York *Electrical Engineer* of a remarkable lecture by Mr. Tesla, which has created extreme interest in America:

The Wednesday evening session of the American Institute of Electrical Engineers was held in Prof. Dwight's room, Columbia College, and will long be remembered by those present, not only on account of the brilliant experiments shown, but also for the many possibilities which it suggested in the development of the artificial illumination of the future. For the purpose of his experiments, Mr. Tesla employed the alternating machine with 400 poles, already alluded to, which, when run at full speed, permitted him to obtain 20,000 alternations per second. The currents of this machine in all of Mr. Tesla's experiments were first run through a condenser in order to avoid the possibility of injury to the machine. The machine itself was set up in the electrical workshop of the college and was driven by an electric motor, the speed of which could be varied by a switch on the lecture platform.

Mr. Tesla introduced his subject by the remark that modern science has been able to make rapid strides by the recognition of ether as the medium of transmission of vibrations of various forms which manifest themselves to our senses. We are therefore able now to see things in a different light than was formerly the case, and being tolerably well able to explain them, the truth cannot be hidden much longer. The answer to the question, "What is Electricity?" we were not yet prepared to give. We were justified in assuming, however, that electric phenomena are ether phenomena, and we may consider the phenomena of static electricity as phenomena of ether under strain, and those of dynamic electricity and electro-magnetism as phenomena of ether in motion.

Mr. Tesla, while expressing the highest consideration for the work of Dr. Lodge, was not in entire accord with the views advanced by him, which he considered to be more of the nature of ingenious explanations than of a probable theory, Mr. Tesla contending that there can be no two electricities.

Alluding further to the electromagnetic theory of light, and to the Hertz experiments and those of Dr. Lodge and their application to the production of an efficient source of light, Mr. Tesla considered the electromagnetic waves as unavailable for the production of luminous effects, for the reason that long before we could reach the necessary frequency the conductor would become opaque to the passage of the waves. Mr. Tesla thought that electromagnetic waves, unless they have the frequency of true light waves, cannot produce luminous effects. Not so, however, with the electrostatic waves or thrusts. These, no matter what their frequency, can excite luminous radiation. He reasoned that the static effects in the Hertz and Lodge experiments were excessively small, due to the fact that they were produced in a practically closed coil, the spark acting as a bridge, making the coil practically continuous and depressing the potential. To obtain the desired difference of potential we must work with an open-circuit generator of high potential of high frequency to enhance the electrostatic effects, and it was the recognition of this fact which led Mr. Tesla to the results he showed.

In carrying out this idea of obtaining enormous differences of potential, Mr. Tesla at once encountered the difficulty of obtaining the requisite insulation for the induction coil employed by him. His experience demonstrated that what we consider the best insulators—such as glass and rubber—are inferior to others, not formerly so considered—such as oil and wax. Mr. Tesla then started a spark coil in action, the primary of which was in connection with his alternator, which was speeded to give from 10,000 to 11,000 alternations per second. The coil emitted a clear note, which rose as the number of alternations was increased. As the discharges took place between the terminals of the coil an exhausted Geissler tube held in proximity to the discharge did not light, but upon blowing out the arc the tube lighted up, which was due to the rise of potential caused by the rupture of the arc. This effect Mr. Tesla considered as purely electrostatic.

Mr. Tesla then showed the influence of insulated bodies having considerable size upon the spark length, demonstrating the effect of capacity upon the nature of the discharge. Thus, when we attach an insulated body to the terminal of the coil, the potential may be raised or lowered. He showed this by wrapping an insulated wire of about 1ft. in length about one terminal of the coil, and touching the other terminal with a brass sphere held in the hand: under these conditions streams of light emanated from all sides of the wire. When the sphere was removed, however, the streams disappeared almost entirely. He then cut off the wire in successive lengths, and the stream discharges became more marked and brilliant. He then attached a fine platinum wire to the terminal, which also showed the streams to a remarkable degree, and kept up a continuous vibration to and fro. He also showed a pinwheel effect, the wheel being rapidly rotated with streams issuing from the two points. Another experiment consisted in attaching two spheres of about 4in. diameter to the terminals. The spark passes first between the two points nearest to each other on the spheres, then works up toward their tops, is extinguished and is re-established at the first point, this being continuously repeated. The neighbouring exhausted tubes and lamps were illuminated and extinguished in unison with the action of the spark between the spheres. These Mr. Tesla pointed out were not electromagnetic vibrations like the Hertz waves. He showed how by the use of the dielectric the spark is induced to jump between the separated spheres due to the increase in the specific inductive capacity of the medium, and he also demonstrated that the streaming discharge passed easily through thick glass plates, rubber plates, and a book. Mr. Tesla then showed these static effects in a non-striking vacuum. A tube of this nature when connected to the machine glowed brightly, and the terminals became incandescent. Mr. Tesla then remarked that if, instead of using a filament in a lamp—which necessarily limited us in the degree of incandescence which we could practically employ, —we could employ solid blocks of carbon, much higher efficiency could be obtained. Based upon this reasoning, he has constructed a lamp, which he showed, containing two blocks of carbon in non-striking vacuum. When connecting these two carbons to the two terminals of the coil, or one to one terminal and the other to a body of some size, the blocks can be raised to high incandescence.

Mr. Tesla also showed a lamp with but a single rod filament in a non-striking vacuum with no outward connection. The energy is entirely transferred by condenser action through the medium of condenser coatings in the base of the lamp. He also pointed out how the brilliancy of the lamp could be varied by simply altering the relative positions of the condenser coatings. This Mr. Tesla followed by demonstration of the phenomena with an unexhausted globe, and a single filament mounted therein. The filament when connected to one terminal of the coil heats up to bright incandescence, and spins around in the globe. He also demonstrated the heating by the use of Crookes's well-known apparatus, consisting of mica vanes mounted above a platinum wire, which was brought to incandescence by connection with one terminal of the coil, and rotated the mica vanes.

In order to still further verify the conclusions that the electrostatic effects are alone active, Mr. Tesla placed a Geissler tube at right angles to the coil and at its centre. In this position the tube did not light up. When placed at the ends, however, the tube lit up brilliantly and gave sufficient light to read by. Mr. Tesla showed both uranium and yttria tubes.

He then showed how exhausted tubes could be made to glow in an electrostatic field. For this purpose two large sheets of zinc were connected to the terminals of the machine at a distance of about 15ft. apart. The tube when placed between these sheets glowed brilliantly and could be moved about freely. Mr: Tesla remarked that, by merely creating such a field in a room, the mere suspension of the tubes in the room would afford the desired illumination.

Coming to the physiological effects, Mr. Tesla adjusted the conditions so that by touching one terminal with a brass sphere he raised the potential of the coil so enormously that a stream of light came out on the other terminal, and he estimated the difference of potential to be nearly 250,000 volts, and then performed the remarkable experiment of receiving the total discharge in his body, protecting his hands from burning by the brass balls held in his hands.

He then lit up lamps by holding them in contact with one terminal or near to the coil.

The lecturer then came to another class of experiments. He stated that he had used a system of conversion from high tension to low with the enormous frequencies of the condenser discharges. Mr. Tesla then showed an interesting experiment, which consisted in passing the converted currents, produced in the manner just described, through a copper bar ⅜in. in diameter and bent into a loop. Ordinarily such a bar would constitute a short circuit, but Mr. Tesla succeeded in bringing lamps stretched across the parallel sides of the bar to incandescence, demonstrating that the impedance in the loop connecting the two sides was so great as to practically prevent the current from passing through it and hence acting upon the lamps in the manner described. He also pointed out the existence of nodes on the bar. His method consists in continuously charging and disruptively discharging a condenser into the working circuit, the charging of the condenser being effected by a coil operated either by alternating or direct currents. By this means any desired higher frequency may be obtained from any lower frequency.

We have given but the merest outline of the many beautiful and highly suggestive experiments made by Mr. Tesla. Notwithstanding the fact that Mr. Tesla excited the intensest interest of his audience for three hours, he was nevertheless unable, for lack of time, to bring before them many experiments, some of which, he said, were even of a more striking nature than those brought out.

Madras Lighthouse.—The present granite column that acts as a lighthouse in Madras has been found to interfere with the architectural symmetry of the neighbouring structure, and is to be pulled down. The lighthouse arrangements are to be transferred to the new building. New beacon lights are to be erected at the entrance of the Madras Harbour.

FACTORY LIGHTING.

The advantages of electric lighting in factories are admirably and statistically illustrated in the report of the Chief Inspector of Factories for last year, in which the following appears:

"The introduction of the electric light into factories will conduce very much to the healthiness of some occupations and the comfort of all. Mr. Beaumont, H.M. Inspector for Bradford, has procured the following comparison of the temperature in a wool-combing shed when lighted by electricity and by gas light during 24 hours:

Time.	Electricity.	Gas.	Time.	Electricity.	Gas.
	Deg.	Deg.		Deg.	Deg.
7 p.m.	93	95	2 a.m.	95	108
8 ,, ...	94	101	3 ,, ...	95	107
9 ,, ...	94	104	4 ,, ...	95	107
10 ,, ...	95	106	5 ,, ...	95	107
11 ,, ...	96	108	6 ,, ...	95	107
12 ,, ...	96	109			
1 a.m.	96	108	Average...	95 deg.	105·1°

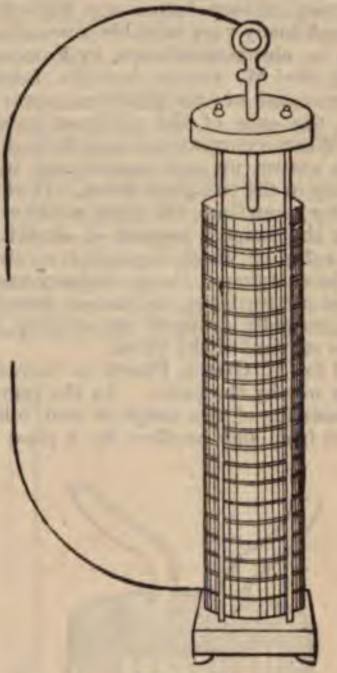
Wool-combing requires that the machine should be heated, and as the operations continue frequently night and day it will be readily conceived what the condition of the atmosphere must be when heated by the machinery and the gas.

ELECTRICAL STORAGE BATTERIES.*

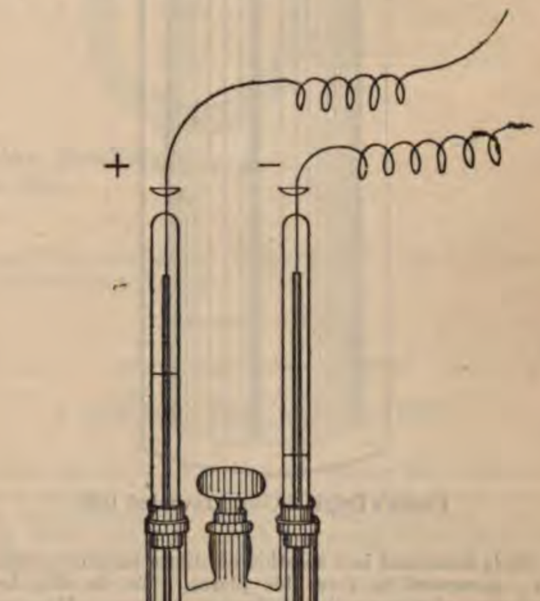
BY H. B. VORLEY, A.I.E.E.

The subject of the conservation of energy has always been one which has engaged the attention of engineers, but the law of the indestructibility of energy has not always received at their hands the same attention as that of the indestructibility of matter. It must, however, be apparent to all that to concentrate, store, and preserve energy for future use must be an immense advantage. Instances of mechanical storage are seen every day. For example, in the ordinary spiral spring energy is expended in the compression, and remains stored up until the release, when it is again developed and work done, or, in other words, remains potential until the release, when it becomes kinetic. Again, we expend energy in raising a weight to the summit of an incline, which remains stored up until the weight is allowed to fall to the base. In both cases we are expending energy in opposing some natural force—in one case the power of gravity, and in the other the elasticity of the spring. Now, electricity being a form of energy, it is natural to suppose that it, too, can by some means be practically stored, and, in fact, the equivalent is found in the storage battery. As in the cases of the spring and weight, energy is expended in respectively compressing and raising them, so it is also expended in passing a current of electricity into a storage battery, where it either remains latent or is taken out and developed in the form of work. To take a common illustration, a storage battery is like a reservoir or cistern, into which electric energy is pumped, and can be drawn off at any subsequent period.

One of the earliest methods of electrical storage is seen in the condenser, and in the well-known Leyden jar, with which we are all so familiar. You will remember that, after charging the jar with a frictional or Wimshurst machine, the surfaces of the tinfoil will remain charged until we unite with a metal rod the exterior and interior foils, which is known as discharging the jar. A proof is then given of the presence of the electricity by the spark which ensues at the discharge, but if a stronger proof be required, let the jar be discharged by touching the brass knob with the hand, when the presence of electricity will make itself known in a manner more convincing than pleasant. Now, in the days when the only means of generating electricity was by frictional and influence machines, the Leyden jar answered its purpose very well, as it was capable of receiving an erratic charge of electricity, storing it up, and discharging itself in the same erratic fashion; but when electricity came to be produced by primary batteries, and later on by dynamo machines, the purpose of the Leyden jar utterly failed. Electricity was no longer something whose strength could not be relied on, could hardly be measured, and as fickle as the wind, but now became a continuous current of a certain definite strength, measurable both in its pressure and in its quantity. The Leyden jar could not be charged by either primary batteries or by dynamos, and would not discharge its current slowly or a little at a time, but in one sudden flash. The necessity which was thus created has now been satisfied by the gradual development, during the last 20 years or so, of the secondary battery, and although its progress has been and still is very slow, yet it is every day becoming a very important factor in electric lighting and traction.



Volta's Pile.



Sir Wm. Grove's Gas Battery. Invented 1842.

As many of our most important inventions have been suggested by observing simple laws in Nature, so was it with the storage battery. In 1803 a man named Ritter, of Jena, noticed that on passing a current of electricity through a Volta's pile, it immediately after had the power of giving off an electric shock. He thereupon made a series of experiments in piles, and tried various metals for his discs, but finally settled on copper, and accordingly built up his pile of copper discs, separated by cloth moistened with sal-ammoniac. The instrument demonstrated the fact that the pile would distinctly give back the charge it had received, but further than that it was of no practical value, as its capacity was too small, and its efficiency too low.

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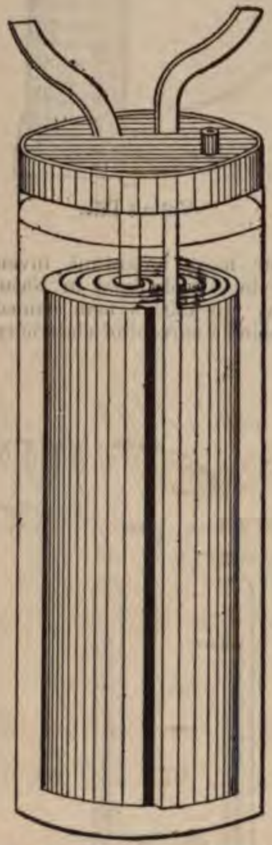
* Paper read before the Junior Engineering Society.

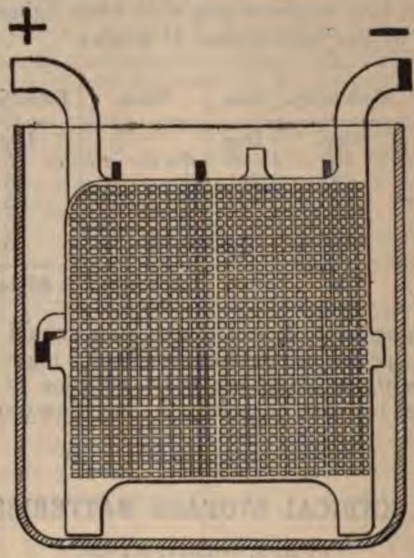
A long period now elapsed before any important discovery was made, although many very valuable researches were made in the meantime in electrometallurgy by Faraday, Davy, and others. In 1842 Sir W. Grove brought forward his gas battery, which consisted of two platinum pieces immersed in acidulated water, the ends of the platinum passing into two glass test tubes. When a current was sent through the platinum pieces electrolysis was set up, and oxygen and hydrogen were formed respectively in the two glass tubes. If the battery was allowed to stand for some time, the gases would recombine with the liquid, and at the same a current of electricity given off, the strength and value of which depended on the quantity of gas given off in the charging. The gas battery was more or less a piece of laboratory furniture, and never came into any permanent use, but gradually dropped out of date, following the natural law of the survival of the fittest.

It was reserved for M. Gaston Planté to introduce the first secondary battery worthy the name. In the year 1860, Planté built up a cell consisting of two strips of lead rolled up into a coil, but separated from one another by a piece of cloth, and the whole immersed in a solution of dilute sulphuric acid. He then commenced to form his plates. To do this he subjected the plates to the following process: He passed a current of electricity through the cell, and the plate which received the current from the positive side was noticed to become covered with a brown film—viz., peroxide of lead. If the cell were now short-circuited it was found capable of discharging, even in this condition, a very small current, but during the discharge the brown peroxide disappeared, and the surface of the plate was observed to be eaten away into a soft spongy state. The cell was now charged in the reverse direction, and the film of peroxide was formed on the opposite plate. The cell was now discharged as before. The operation of charging, discharging, reversing, and so on was continually repeated, and, according to Planté, after several months the plates were found to be reduced to the spongy form of lead, and the plates were said to be formed. The cell was now capable of storing a considerable current, and the positive plate became coated with peroxide of lead, while the negative plate remained in a state of firmly-divided metallic lead. After the trouble of forming the plates the chief objection to Planté's cells seems to be, that in order to keep them in good condition frequent reversals are necessary, and after this has been continued for some time the plates get *more and more* eaten away, and are liable to become rotten and *break away. It is said, however,* that it is possible to discharge these batteries very rapidly, and that this rapid discharge does not injure the plates at all.

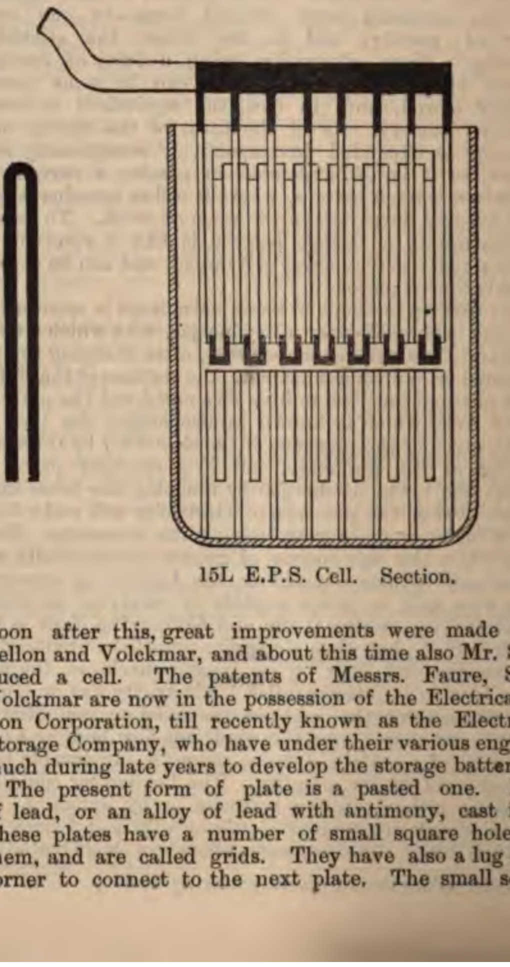


Plante's Original Cell. Invented 1860.

The next most important improvement in storage batteries was made in the year 1880, when it will be within the memory of many here present that the Press of that date confidently asserted that the problem of the storage of electricity was solved. Up to this date the cells of Planté had been used more experimentally than practically, and it was just at this period, when the dynamo was developing so rapidly, that a great improvement was made in Planté cells. It occurred to M. Camille Faure that instead of forming a plate by continually charging, reversing, and recharging in order to reduce the lead to the spongy state, that the same object would be attained if he coated his plates with a paste of peroxide of lead. For this purpose he coated his plates with minium and red lead, which only required a long and continuous charge, in order to reduce them to the proper conditions. The plates were not rolled up in spiral form, as in Planté's cells, but placed side by side, alternately positive and negative, at a distance apart of between $\frac{1}{4}$in. and $\frac{1}{2}$in. These plates were painted with red lead and then covered with felt to make the paste adhere, and were found capable of a very slow discharge, and their efficiency was decidedly higher than those of Planté.



15L E.P.S. Cell, showing Empty Grid.



15L E.P.S. Cell. Section.

Soon after this, great improvements were made by Messrs. Sellon and Volckmar, and about this time also Mr. Swan introduced a cell. The patents of Messrs. Faure, Sellon, and Volckmar are now in the possession of the Electrical Construction Corporation, till recently known as the Electrical Power Storage Company, who have under their various engineers done much during late years to develop the storage battery.

The present form of plate is a pasted one. It consists of lead, or an alloy of lead with antimony, cast into plates. These plates have a number of small square holes cast into them, and are called grids. They have also a lug cast in one corner to connect to the next plate. The small square holes are to receive the paste, or, as it is technically called, the active material, and are slightly undercut, so as to prevent the paste from falling out. The positives are filled with peroxide of lead, mixed with sulphuric acid, while the negatives are filled with litharge, also mixed with sulphuric acid, in order to keep the material coherent. The lugs of the plates are fastened together, positives and negatives respectively, by a strip of lead, which was formerly soldered on, but is now burnt on. The plates interlace, so that there is always a positive opposite a negative, and *vice versâ*. There is always one more negative than positive plate, so that each positive is always encased on either side by a negative. Each plate is separated from its neighbour by three ebonite hairpin-shaped strips. In addition to the bars of lead that connect the lugs, the negative plates are all joined together by a bar on either side, on which the positives sit in vulcanite sockets, while the positives have a bar running along the top to unite them. The cells are placed on wooden trestles in the shade, and stand on wooden trays containing sawdust to absorb any acid that may drop over, and the trays stand in oil cups, so that the cells may be completely electrically insulated. The electrolyte of the cell is sulphuric acid diluted to the specific gravity of 1·170, or about 2 per cent. of acid. When the plates have been immersed in the electrolyte, the cell is charged with a heavy current, continuously and for a long time, causing the paste in the positives to become lead peroxide, and, in fact, the positive grids themselves, whilst the negatives become more and more spongy. The positives then assume a dark red colour, whilst the negatives remain grey. When this process has been gone through, the plates are said to be formed, and are ready to be delivered to customers. After setting up the batteries there should be another long and continuous charge. According to Sir David Salomons, this should continue 30 hours, if possible, or not less than 10 hours per day during three days for the usual size of cells, when the liquid in them will commence to boil, having a milky appearance, due to the quantity of gas bubbling through the liquid by the current setting up electrolysis in the liquid; the specific gravity will rise to about 1·200 by the hydrometer, the reason for which will be explained later. The chemical action which takes place in a storage battery is as follows: The $PbSO_4$ becomes PbO, whilst the SO_4 goes to the electrolyte in exchange for O, the H_2 of the water joining with the SO_4 to form H_2SO_4. Another atom of O now joins the positive plate, while the liberated H_2 joins with the O of the negative plate to form water, leaving the negative plate lead pure and simple.

Positive.		Electrolyte.		Negative.
$PbSO^4$	....	$H^2SO^4+H^2O$	....	PbO
PbO	....	$H^2SO^4+H^2O$	....	PbO
PbO^2	....	$H^2SO^4+H^2O$	....	Pb

Chemical action in a cell during charge.

It will be noticed that the specific gravity of the electrolyte is greater when the cell is charged than at other times. This is owing to the sulphate leaving the positive plate, and joining with the H_2 of the water to form sulphuric acid. The specific gravity of the electrolyte therefore forms a method of ascertaining the electrical condition of the cells, and, as a matter of fact, this is one of the methods of finding out the amount of charge in a cell. The hydrometer is used for the purpose; this is merely a closed and weighted glass tube which floats at different levels according to the gravity of the liquid, the tube being graduated so that the gravity can easily be read off on the side.

The chemical process which takes place when a cell is discharged is practically the reverse of charging. To explain as simply as possible, and to give a good illustration of what goes on in a storage cell, let us look at the diagram, where two U-tubes represent the positions of charge and discharge. In 1 we see the liquid is displaced, whilst in 2 it is finding its own level. Now, if we suppose that the liquid represents oxide, in the first case we have an illustration of a cell fully charged, and waiting to discharge, whilst in Fig. 4 the cell is supposed to have been discharged. In order to bring all the oxide to one side—viz., the positive side—one must use a force that will have sufficient strength to overcome the resisting force in the cell itself. In the case of the U-tubes the force to be contended against is gravity, while in the storage cell it is an internal electrical force tending to oppose the efforts of the current to bring the oxide to the positive side. This internal electrical force is called the counter E.M.F., and the opposition which it presents polarisation.

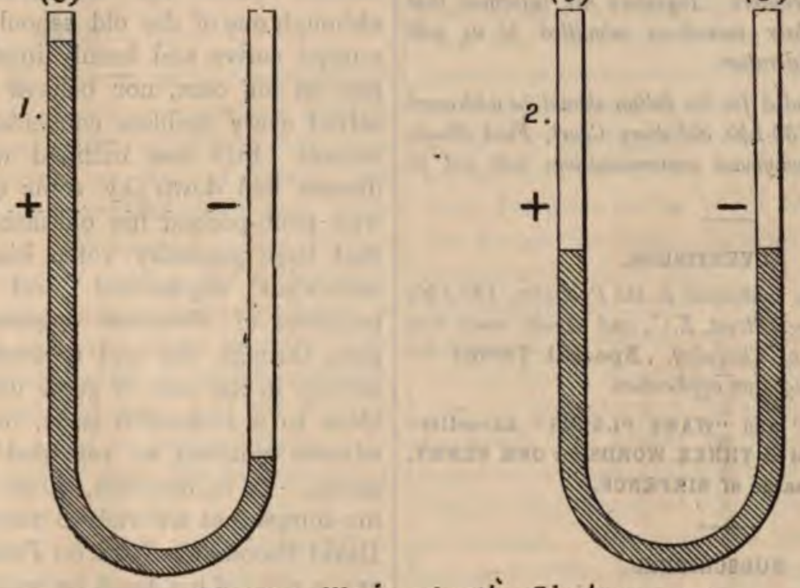


Diagram illustrating the Discharge of a Storage Cell.

(*To be continued.*)

A SIMPLE VOLTAIC BATTERY.

A novel and simple form of electric battery has recently been invented in Italy. It consists of conical vessels of cast iron and porous earthenware, with nitric and sulphuric acid. An iron cone is placed point downwards in a stand, and is partly filled with strong nitric acid. Into this there is placed a cone of porous earthenware containing dilute sulphuric acid. Then follows an iron cone, surmounted by an earthenware one, and so on in a series, each vessel containing its respective acid. It follows that the inner surface of each iron vessel is bathed in nitric acid, and becomes passive, acting the part of the platinum or carbon in an ordinary cell. The outer surface is attacked by the dilute sulphuric acid, and takes the place of the zinc. There are no connections to make, the simple building of the pile putting all the parts into union. The earthenware cones are 8in. in diameter and 4in. in height, and contain 550 cubic centimetres of 10 per cent. sulphuric acid solution. The iron vessel contains 110 cubic centimetres of nitric and sulphuric acids, the latter being three times the volume of the former. Sixty elements, arranged in two piles, have a resistance of $10\frac{1}{2}$ ohms, an E.M.F. on open circuit of 81 volts, and on closed circuit of 45 volts, with a current of $4\frac{4}{10}$ amperes. After five hours the difference of potential falls to 28 volts, and the current to $2\frac{7}{10}$ amperes.

Fontainebleau is to be connected to Paris by telephone.

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

THE LATE DAVID BROOKS.

We regret to record a telegram which brings us the sad information that David Brooks died last Saturday. It is but a few days since we received a characteristic letter from our late friend, which only showed signs of advancing age in the caligraphy. The interest shown in electrical matters was as keen as ever, and we hoped that Brooks might have been spared to do more work. There never was a time in the history of electricity which brought more closely together and helped to form firmer friendship than the 1881 exhibition at Paris. It was our privilege to know David Brooks before this date, but, if possible, we got to know him better, and to cement firmer the friendship that already existed, by daily contact about the exhibition. David Brooks, although one of the old school, kept a young heart, a mind active and keenly intelligent. He did not rest on his oars, nor believe the older men had solved every problem connected with his favourite subject. Still less inclined was he to take the dictum laid down by some of the younger men, who pooh-poohed his old-fashioned views, and at that time generally voted his views of insulation somewhat unpractical and unsuited for the purposes of electrical engineering. Brooks had gone through the mill in matters telegraphic, and having, in the face of great difficulties, brought his ideas to a successful issue, he gave little heed to adverse opinions as regarded the newer developments. It is, however, more of the man than of his doings that we wish to refer to here. The late David Brooks was born on January 26, 1820, so that at the time of his death he was but little over 71—an age which more than completes the scriptural threescore years and ten—but one when many of our scientific men and those engaged in public work are considered to have only reached maturity. Mr. Brooks was one of the most genial and kind-hearted men that we have ever met. He had a rich vein of humour, was filled with anecdotes, and had the happy knack of seldom or never telling the same tale twice to the same audience. The greater part of his life was spent in telegraphic work, but in 1878 he was appointed by General Grant United States Commissioner to the Vienna Exposition. The American report on that exhibition is, in our estimation, one of the best reports that was ever made upon any exhibition. Subsequent to that time Mr. Brooks threw himself with ardour into the development of his system of oil insulation. He devised plans for its use in telegraphy, in telephony, and in electric lighting. An experimental line was laid down by Mr. Brooks for our postal telegraphs, if we remember rightly, in 1880 or 1881. At any rate, an exhibit was in the 1881 exhibition. Mr. Brooks was partial to London. He was also partial to a good dinner and to good music, and many a jovial evening was spent with a small party at those restaurants where music enlivens the dinner. He managed frequently to get favourite pieces played either in addition to the ordinary programme or as a change. Since 1881 he has visited Europe several times; the last time we believe was about two years ago, for the purpose of initiating Messrs. Johnson and Phillips into the mysteries of his system of insulation. Recent experiments of Kapp in England, and Brown at Oerlikon, have shown that this system possesses many advantages that will surely cause its adoption under suitable conditions. A short series of papers had just been commenced in our American contemporary and namesake and in this paper on Brooks's system.

We are quite sure that the many friends of the late David Brooks will agree in the expression of our heartiest sympathy with his family in the loss they have sustained.

BATH.

Mr. Massingham at Bath is to be congratulated upon the energy he is showing in pushing electric light enterprise. The Bath installation has been watched with a certain amount of doubt, but although changes in various details have been made since the inauguration of the light, each change has been for the purpose of making the distribution better and overcoming minor faults developed in practice. A casual visit the other evening found Mr. Massingham not neglectful of superintendence, found the engineer at his post, and all running smoothly. Of course, just at present there is no great demand for current. One Mordey alternator, therefore, is generally sufficient to supply the demand, but a second is kept running slowly to take up the requirements at any moment. Since the beginning of the year two alternators with their corresponding engines have been erected, the continued demand indicating that with the next season the plant, as now doubled, will be none too extensive. We examined, as far as was possible during the few days, or evenings, at disposal, the street lighting, and if our opinions can be unbiassed, they are to the effect that gas is not in the running. Here and there the arc light was "blinking," but most of the lamps were steady enough while watched. A plan which might commend itself to other companies, is effective in showing what can be done in a simple manner with the light. Arrangements were made with the principal gasfitter in Bath (Mr. Davis) to give equal prominence to electric light fittings as to gas fittings. One side of the shop window contains a nice display of such fittings, to many of which, in the evenings, lighted lamps are attached, and the whole, as we say, form a very effective advertisement appealing to the passers-by. The incandescent lighting seems almost perfect, and we were glad to hear that the demand for the installation of lamps was increasing, the latest being for a club which will require about 200 lamps. Not satisfied with the display in Bath, Mr. Massingham has taken the opportunity of the meeting of the Bath and West and Southern Counties Agricultural Society, now being held at Bath, to have a very fine interior exhibit in the grounds. The lamps are capitally arranged, the fittings being very tasteful and simple in design, the whole being perfect lighting. The current for the lighting at the show is from a Taunton dynamo, of which, indeed, there are several, driven by engines in the showyard. These dynamos, so far as we examined them, run smoothly, without sparking, and without heating. It is undoubtedly due greatly to the individual enterprise of Mr. Massingham that electric lighting is held in such high repute in the West.

EDISON'S LATEST.

As yet it is hardly possible to say exactly in what "Edison's latest" consists. It is a combination of phonograph, photography, and lantern work to reproduce the vocal sounds and visible sights upon an operatic or other stage. So far as phonography is concerned, Edison may claim all the credit, but so far as the photographic reproduction is concerned we are inclined to the opinion that Mr. Rudge, of Bath, has prior claims which will hardly be disputed. Mr. Rudge has quite recently perfected an electric arrangement which greatly assists in giving a faithful reproduction upon the screen of what we may term continuity of action. By means also of an optical arrangement, not generally known, Mr. Rudge is able to project upon the screen a series of pictures in which the action seems continuous from one point to another. The eyelids seem to move, or the lips, or the arms, or whatever part of the body is in motion. We hope ere long to give a detailed account of Mr. Rudge's apparatus.

THE UTILISATION OF WATER POWER.

Colonel Turettini has recently presented a report upon the utilisation of the water power of the Rhone, near Geneva, which makes very interesting and instructive reading for electrical engineers. There is available a force of 4,400 h.p., of which one half is now utilised. The turbines have supplied power during the past year for 1,565 electric motors of very varying size. Many of these are small motors of ½ h.p. used for driving sewing machines, or other domestic or manufacturing apparatus, and from this they range upwards to motors of over 600 h.p., which are used for the production of electric light. The cost of the erection of the station is given at 5,600,000f. (£225,000), and the receipts for 1890 are 2,120,000f. (£85,000). A result apparently so encouraging cannot but have its result in the fostering of similar enterprises elsewhere.

TESLA'S EXPERIMENTS.

We give in another column an account of a remarkable lecture given by Mr. Tesla, which seems to promise the inauguration of a new field of practical research and usefulness by the use of alternating currents of very high frequency. Mr.

Tesla's attitude is described as that of a veritable magician, holding his hearers wonderstruck for hours. With lamps it seemed to make little difference whether they were lying on the table, or were connected by one pole only, or were short-circuited across the terminals by a thick piece of copper wire traversed by the current. In each and all cases the filaments were brought to incandescence, to the wonder and delight of his audience. He seems even able to bring blocks of carbon in a vacuum to high incandescence by condenser action, with a far higher illuminating efficiency than is possible with filaments. It is too early as yet to judge deliberately of the effect these experiments and researches may have, but it seems to be thought that their practical usefulness is quite within immediate reach. The full text and illustrations of the paper will be awaited with great interest.

THE WADDELL-ENTZ ALKALINE STORAGE BATTERY SYSTEM.

Accumulator cars have been appearing with a certain wearisome periodicity ever since the experiments of Faure evolved the modern storage battery. It is so seldom, however, that one can conscientiously say anything good of them that an occasion like the one about to be described is a somewhat noteworthy event in electrical circles. On Monday, May 4, a public test of the Waddell-Entz storage battery car was held in Philadelphia, and its success was so unusual as to attract very widespread attention. The inventors of the apparatus, Messrs. J. B. Entz and Montgomery Waddell, of New York, have been working quietly along, making experiments for the past year, and have made some preliminary tests with a car equipped with their devices on the Brooklyn and Coney Island road. About a month ago the car was put on one of the Philadelphia lines near Germantown Junction, and has been undergoing a series of experiments ever since. These have been so successful as to warrant the public exhibition that has just been held.

Unlike most storage battery cars, something more was involved in the present one than a storage battery warranted not to buckle and a motor of crude and unusual design. The features of the Waddell-Entz apparatus are three: First, the use of an alkaline accumulator; second, the employment of a particularly light slow-speed motor; and, third, practical arrangements for utilising the motor as a dynamo on down grades to recover a certain proportion of the energy used in storing the battery. Nearly all the work that has been done on accumulators has been devoted to the lead type, in which the electrodes are leaden grids of infinitely various forms packed in one way or another with oxides of lead. The E.M.F. of such cells is high, as every electrician knows, between 2 and 2·4 volts per cell, but the weight is enormous and the durability anything but what could be desired.

The deterioration of lead storage batteries occurs partially through irreversible chemical processes going on in the cell, and also through the mechanical action produced by these chemical processes on the active material of the plate, the result being that the grids are, from a swelling and distortion of the plugs of active material within them, twisted out of shape so that the battery is short-circuited. This fault occurs in the positive plates, and is known as buckling; it is the peculiar difficulty with ordinary storage batteries. Whenever one attempts to force the output of a cell and draw from it an unusually large current, the result is a tendency to buckle the plate; and when, as in street-car work, severe demands are made upon the battery many times in the course of a trip, the effect is disastrous, and a very few months is found to destroy the usefulness of the cell, either through buckling, or through disintegration of the active material.

In experiments carried on by a very large number of people all over the world during the last decade, the uniform fate of positive plates has been found to be rapid disintegration as soon as they were put to any severe service. Of course, there have been occasional exceptions; but the fault is so general as to be well nigh universal, and has its origin in the nature of the chemical actions in the cell and their effect upon the physical characteristics of the active material. The weight of the average lead accumulator is about 100lb. per horse-power hour stored, and the efficiency under ordinary conditions somewhere near 80 per cent., this latter depending almost entirely on the rates of charge and discharge, and the care that is taken of the cell.

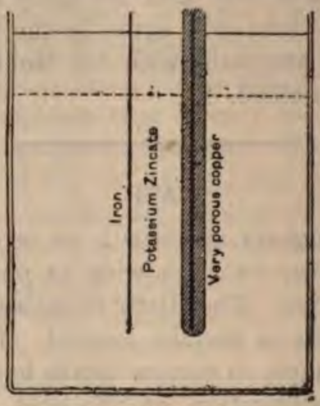

Fig. 1.—Waddell-Entz Storage Cell

The inventors of the system under discussion, for reasons like those enumerated, avoided the lead type of battery and adopted a very promising kind of accumulator that sprung into notoriety in France some two or three years ago; this is the alkaline accumulator brought out by Desmazures and his associates. It is, chemically, strikingly similar to the Lalande-Chaperon battery, known here with slight modifications as the Edison-Lalande. The alkaline accumulator has for its two metallic elements copper and zinc, and for the electrolyte caustic potash. The zinc is deposited upon iron electrodes, while the copper is exceedingly porous and capable of very ready oxidation.

Figs. 1 shows in diagram the character of the cell. The solution of the cell is really potassium zincate. The action on charging is to deposit metallic zinc on the iron electrode, which latter is generally in the form of a tinned gauze, and to oxidise the porous copper. On closed circuit the zinc is dissolved with the formation of potassium zincate and the oxide of copper is reduced. A porous partition is placed between the two elements, originally made of parchment paper. The E.M.F. of such a couple is small, ·8 to ·9 of a volt, but the chemical action is almost completely reversible and the output very great in proportion to the weight.

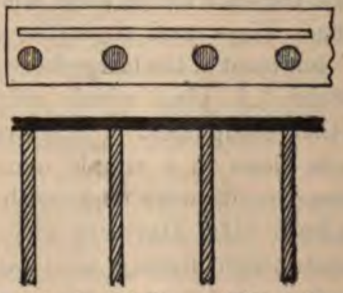

Fig. 2.—Sketch Plan and Side View.

The Desmazures accumulator was made with a plate of copper obtained by the compression of copper dust, giving a consistent mass, though the result showed it somewhat lacking in the necessary porosity. The batteries were adopted by the French Government for the important experiments carried out on submarine torpedo boats and furnished the power for the operation of the "La Gymnote," that made something of a sensation in the naval world a little over a year ago. The outcome of a great deal of experimentation showed that the efficiency of the alkaline battery was practically the same as that of a lead battery, while its weight could be easily reduced to a point unapproachable by any practicable form of the old accumulator. The weight of the alkaline accumulator per horse-power hour proved to be from 55lb. to 60lb., and there was nothing like the buckling that has proved so fatal to the positive plates of ordinary storage batteries. Such is the battery that Messrs. Waddell and Entz took up with a view to reducing it to a thoroughly practical form. Difficulties of a serious nature have been found with it, notably a great increase in resistance of the copper positive plates after a little use, and a serious amount of local action on open circuit. These great faults have been in a very large measure eliminated; the first by the employment of vastly more porous copper than was used by the French experimenters, thus allowing freer access to the reducing agent and preventing the irreversible oxidation that had before been found.

The second difficulty was in the original Desmazures battery due largely to defects in the parchment paper envelope, which in the present case is replaced by a textile one that gives vastly better results. In the Entz battery, too, the porous copper is furnished with a permanent backing of dense copper that is entirely unaffected in the action of the cell, and consequently keeps up the conductivity. Figs. 1 and 2 show in diagram the general character of the resulting cell. The copper electrode is made with a dense copper core, surrounded by exceedingly porous copper, and the whole enclosed in a textile covering. The liquid is potassium zincate, and the other electrode is of iron, permitting the deposition of the zinc. As a matter of fact, numerous plates are employed in each cell, just as in the ordinary lead battery, and the walls of the cell itself are of iron, and form a portion of the negative pole.

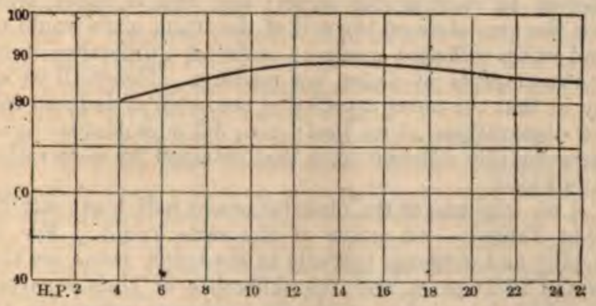

FIG. 3.—Efficiency Curve of the Waddell-Entz Motor.

The result of these small but important changes made by the American inventors is a battery that, like its prototype, weighs about 55lb. or 60lb. per h.p. stored, has an efficiency equivalent to that of the best lead storage batteries, and a power of resisting enormous discharges and working under very severe conditions that is unequalled, so far as we know, by any of the earlier types. Apparently, the faults of the Desmazures battery have been successfully overcome. In the car used in Philadelphia, 100 battery cells, weighing, complete and filled, 30lb. apiece, and each 5in. × 7in. × 11in. were employed, giving from 74 to 80 volts at normal output. This battery is capable of delivering as high as 300 amperes without the evolution of gas or serious heating. It is stored under the seats of the car, as is the usual practice, and is, for the purposes of governing and recharging, divided into several sets of cells. It will thus be seen that the battery equipment is very light, weighing, as it does, only about 60 per cent. as much as a lead battery of equal capacity. The gain in weight of battery per car is something like 1,500lb.; the car is driven by a single carefully designed low-speed motor. It is of unusual design, inasmuch as the armature is a Gramme ring with internal fixed field magnets; the latter are magnetised by a single coil around a central shank. Two four-armed spiders upon the ends of this give the alternating north and south poles; the ring armature is 21½in. in diameter over all and has a depth of core of about 1½in. It is wound, of course, with a heavy wire, for it is designed for a low voltage and large quantity of current. There are four carbon brushes, the several portions of the armature being thrown in parallel with each other; the whole is enclosed in a frame of non-magnetic material. The armature speed for a car speed of 10 miles is about 450 revolutions per minute, and the power is transmitted to the axle through a single pair of gears, the speed reduction being about five to one. The armature pinion is case-hardened, and acts on a wooden axle gear, so that the car runs very quietly. The advantages of this peculiar type of motor are in the large and well-ventilated armature, giving a powerful torque, and permitting the use of very heavy currents without excessive heating; and second, in the simple form of the field magnets, enabling magnetism to be obtained with comparatively small expenditure of energy. The actual maximum efficiency of the motor is satisfactory without being phenomenal. The machine was designed, however, to give its maximum efficiency at something like its average output. Fig. 3 shows its efficiency curve at various loads. The motor being nominally of 20 h.p., its point of maximum efficiency is at about 15 h.p., and even at 15 h.p., its normal load, the efficiency will be seen to be 80 per cent. This is not a remarkable figure, but it gives a good all-round commercial efficiency even under widely varying loads. The use of a single motor once geared is in itself a decided advantage, as it both increases the commercial efficiency by avoiding multiplicity of gears and also reduces the working weight of the equipment. The motor and the regulating devices together weigh less than 1,500lb., with the result that the total weight of batteries, motor, and regulating appliances in this Waddell-Entz car is less than that of the motor equipment of the standard cars used on the trolley system. This means a very decided saving in power, for one of the besetting sins of the storage battery system has been the excessive weight of equipment, every extra pound of which meant extra coal burned at the power station. Of course, the same or similar motors could be used for the trolley system if desired, although such has not been the usual practice. The total weight of the copper in the motor is 130lb., a very satisfactory result for a motor intended for such exceedingly heavy currents. The regulating appliances of the car are interesting. The platform switch has six steps. Of these the first throws on the batteries, four in multiple, to start the car, the second changes this arrangement to two in multiple, the third throws all the cells in series, while the fourth and fifth cut out section of the field, and the sixth reverses the motor on its lowest speed. The motors when the car is running down hill can operate as dynamos and restore energy to the batteries. This feature of the system is of practical use, of course, only on roads with perceptible grades, but under such circumstances it is undoubtedly somewhat effective, possibly saving as much as 10 per cent. of the energy. The road over which the trial trip was made is almost exactly three miles in length, giving a six-mile round trip for the car, and the power required to charge the batteries for the work is very nearly six horse-power hours, practically one horse-power hour per car mile. The total capacity of the batteries is, of course, much greater than this, sufficient for, perhaps, half a day of ordinary service. This result of one horse-power hour per car mile at the power station is immensely satisfactory; it is unquestionably better than has been usually obtained by storage battery cars, and compares very favourably with the output shown to be necessary on trolley roads, which, however, it should be said, have heavier grades and a heavier car equipment than the one we are considering. The trial trip was a thorough and complete success. The car ran smoothly and regularly, and its motion down grades was reported to be exceedingly easy, owing to the reversal of the motors and the braking action of their use as dynamos. In the same way stopping is accomplished within the length of a car, and very smoothly, owing to the device just mentioned. Readings were taken with Weston ammeters and voltmeters every 10 seconds, and the result showed clearly the ability of the batteries to stand a very heavy output without serious drop in their power. The tests showed that during certain periods energy was being restored to the battery. The running speed in the test was 10 miles per hour, the three miles being covered in 18 minutes. Altogether, this alkaline storage battery motor system seems to be a very useful addition to the methods of electric traction, certainly the most promising that has appeared for some time in the way of proper equipment for city service. Of course, time alone will tell its success when operated by unskilled labour under adverse conditions, but the results obtained are certainly such as to warrant a considerable degree of encouragement to the advocates of storage battery traction.—*Electrical World.*

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING, MEMBER.

(Continued from page 534.)

We may examine how far the capacity value so deduced agrees with measurement.

We tabulate in columns the values of the condenser currents, I, found from Table II., and set against these the mean potential difference of the inner and outer members of the cable as the mean potential difference of the surfaces of the condenser. Calling these last values V, we then calculate the capacity, C, in microfarads from the formula,

$$C = \frac{I}{pV} \times 10^6,$$

on the assumption that $p = 400$. These results are set down in Table III. The values of the potential, V, are the means of the pressures given in columns V. and VII. of Table I. as the pressures at the step-up and step-down end of the trunk main.

TABLE III.

Condenser currents, I, in amperes, taken from Table II.	Mean potential difference of condenser surfaces, V, of cable, in volts.	Calculated capacity for the whole length of cable in microfarads.
12·2	9,005	3·4
14·4	9,935	3·6
15·5	10,210	3·8
12·2	9,020	3·4
14·4	9,635	3·7
13·1	9,440	3·5

The mean electrostatic capacity of the 11·5 statute miles of the cable in use is therefore about 3·6 microfarads, as deduced from these experiments. On the day following these experiments the electrostatic capacity was measured at Deptford by Mr. H. R. Kempe, using a microfarad standard and a battery of about 18 Daniell cells, and taking galvanometer throw observations in the usual way. Mr. Kempe found the capacity under these circumstances of the respective mains to be about 1·98 and 2·02 microfarads, or in all about four microfarads. Accordingly, we see that the capacity, as deduced from the mean calculated condenser currents and the observed pressures at the ends of the mains, comes out a little low compared with the measured steady value; but the speeds and pressures were hardly observed with sufficient accuracy to make a closer agreement very likely, and the condenser current values are probably affected by some errors. It may be observed that the effect of a small but definite inductance in the fine-wire circuit of the transformers at the step-up end existing unannulled at full load would be to lower the condenser currents, and hence to lower the calculated capacity. I think it is pretty clear that what may be called the normal condenser current of the 11·5 statute miles of the trunk mains is about 14 or 16 amperes under a working pressure of 10,000 volts at the step-up end of the main, and at a frequency of about 67 for the circuit. This is what is generally observed.

On one occasion, when the writer was engaged with Mr. Ferranti in testing the trunk mains, we had a similar arrangement of the system to that above described—viz., a length of 11·5 statute miles of trunk main looped in London through two step-down and step-up transformers in parallel, and a similar set of transformers at Deptford. Two 100-c.p. lamps were put on the far end of the system at Deptford, just to give indication of a current flowing through the system, otherwise there was no load. When the dynamos were excited so as to give 2,500 volts on the primary side of the step-up transformers, and this raised to 10,000 volts in the mains, we found a current of about 64 amperes going out of the dynamo at 2,500 volts. This would correspond to 16 amperes or so in the trunk mains. The actual working current at this time was merely the magnetising current of the step-down transformers and the normal current required for the lamps. Hence this experiment agreed in showing that the normal condenser current of the trunk mains at 10,000 volts pressure and a frequency of 67 is about 1·4 amperes per mile run of the cable.

19. Let us next examine how far the observations taken with no load on the secondaries of the step-down transformers agrees with the foregoing. In this case we restrict our view to the last eight observations recorded in Table I. The numbers in column IV. give us at once the condenser current of the cable, because there is no sensible current flowing out of the cable except the negligible magnetising current of the transformers.

TABLE IV.

Condenser current, I, in amperes.	Mean potential difference of condenser surfaces of the cable, in volts.	Calculated capacity for the whole length, in microfarads.
11	9,885	2·8
11	9,985	2·8
10	7,295	3·4
5	5,200	2·4
9	5,500	4·1
9	5,900	3·8
10	7,920	3·1
12	9,395	3·2

The variation in the values of the capacity shows that the measurements of the condenser currents are probably affected by considerable errors; and this is likely, seeing that the ammeters on the end of the trunk main would not read with sufficient accuracy to detect a difference of one or two amperes at these low readings. Hence all we can say is, that the mean capacity of the cable as deduced from the observations at no load—viz., 3·3 microfarads—is not extravagantly different from that obtained by observations at full load.

If we take one of the observations at half load—say No. 10 in Table I.—we arrive at the same result. For the ingoing and outgoing currents in the trunk main are then 22 and 17 amperes, and the difference of their squares is 14, which is probably nearly the condenser current in this case; and the mean potential difference of the surfaces of the cable is 10,560 volts; and hence, as before, the capacity comes out 3·3 microfarads for the whole length. Hence, all the observations agree in giving a capacity of from 3·3 to 3·6 microfarads for the total cable in use. It may well be questioned whether for this paraffined-paper dielectric the capacity as determined by a prolonged charge and discharge gives a value which is correctly expressive of the true working capacity of the cable under rapid alternations of charge. It must be remembered that paraffined paper presents usually a considerable absorption effect, and the value of four microfarads for the 11·5 miles, obtained by the usual ballistic galvanometer method, may be, and perhaps is, a value which is higher than that which correctly expresses the true working capacity of the cable under rapidly reversed electric stresses. It is important to have this point investigated for the dielectrics in use in the manufacture of types of concentric cables now employed.

20. Passing to the examination of other points indicated by the observations in Table I., we see that the mean potential difference of the two conductors of the cable is always greater than four times the dynamo terminal pressure as given in column IV.; that is to say, these figures show that the pressure in the trunk main at the dynamo end is always greater than would be the pressure at the terminals of the step-up transformers if the trunk main were disconnected. This may be said to be the fundamental phenomena which has been much dis-described and misunderstood. The values of the pressures as read at the dynamo terminals and at the two ends of the trunk mains show that whenever the system is loaded, and there is a

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* Paper read before the Institution of Electrical Engineers, *May 7, 1891.*

fairly heavy load, there is a fall of pressure down the cable, as there should be, although the actual figures seem to show that this fall of pressure is not quite equal in value to the product of the values of the true resistance of the cable and the current flowing through it. Those cases in which the figures in Table I. seem to show a rise of pressure along the main cannot be accepted as representing the actual facts. When the cable is relieved of all working current, and only traversed by a condenser current, the figures show that the cable is either all at one pressure all along, or else that there may be a slight rise from the step-up end to the step-down end of the cable. I think, however, that there is no good evidence of this rise of pressure from end to end of the cable when not loaded with external load. The chief fact is that, whereas the step-up transformers would, if existing alone, raise the dynamo pressure fourfold, we find that when the cable is heavily loaded the mean potential difference of the conductors exceeds four times the dynamo terminal pressure by something like 5 per cent., and, when the external load is removed, that excess pressure more nearly amounts to about 10 or 15 per cent.

The general fact is quite in accordance with the foregoing theory. When the step-up transformers are heavily loaded, the inductance of their secondary circuits is practically annulled or very much reduced; when they are lightly loaded, it is at once increased. We have seen, in discussing the clock-diagram of E.M.F.'s as applied to this condenser problem, that the increase in pressure which takes place is always an evidence of the presence of inductance in the charging circuit, and that this rise of pressure will augment with increase of inductance in the line or in the step-up transformer. We are unable to test how far the general rise of pressure is in accordance with the foregoing theory, because we have no means of measuring the true mean inductance of the secondary or high-pressure side of the step-up transformers. The presence of capacity in the line always keeps down the inductance of the transformer, because it compels a rather large current to flow into it from the dynamo, even when the work current flowing out of the cable is zero, or nothing more than the magnetising current of the step-down transformers.

21. In the foregoing paragraphs no attempt has been made to enter into a discussion of the physical *modus operandi* of these condenser effects. We can easily construct, as has been frequently done, mechanical analogies, in which the elastic yielding of a spring and the inertia of a heavy body take the place of the capacity and inductance in the electric system. It is possible, however, to overrate the value of this mechanical parallel. It is probable that the actual physical operations taking place to produce these electrical effects are not adequately represented by a mechanical simile in which the inertia-like aspect of self-induction is exclusively regarded, although, of course, such mental representations have their use. Too much hypothesis is often as bad as too little in seeking to connect together observed facts and fundamental principles. We may regard a condenser, when subjected to periodic currents, as a non-dissipative impedance, if the term may be allowed, having also a negative self-induction. A condenser allows a flux of electricity to take place backwards and forwards through its dielectric, and, as far as alternating currents are concerned, it may be said to have a conductivity for electricity.

A condenser of capacity, C, when traversed by periodic condenser currents of frequency, n, acts in any circuit as equivalent to an impedance of magnitude $\frac{1}{Cp}$. It also acts as if it had a negative inductance equal to $\frac{1}{Cp^2}$, p, as usual, standing for $2\pi n$. By a negative inductance $\frac{1}{Cp^2}$ must be understood a power of nullifying positive inductance in a conductor in series with the condenser, numerically to the amount of $\frac{1}{Cp^2}$ henrys. Suppose, then, that a condenser of capacity, C, is placed in series with an inductive resistance of inductance, L, and resistance, R, and a periodic P.D. equal to V_0 permitted to act on the two in series. The resultant inductance of the whole circuit is $L - \frac{1}{Cp^2}$, and the resultant impedance is

$$\sqrt{R^2 + \left(L - \frac{1}{Cp^2}\right)^2 p^2}.$$

Hence the current through the condenser is equal to

$$\frac{V_0}{\sqrt{R^2 + \left(L - \frac{1}{Cp^2}\right)^2 p^2}}.$$

If the potential difference of the two sides of the condenser is called V_1, and the equivalent impedance of the condenser is $\frac{1}{Cp}$, we may consider that the value of V_1 is obtained by taking the product of this so-called impedance of the condenser, $\frac{1}{Cp}$, and the value of the current flowing through it. Hence we have

$$V_1 = \frac{V_0}{\sqrt{R^2 + \left(L - \frac{1}{Cp^2}\right)^2 p^2}} \frac{1}{Cp};$$

but this is the same expression as that deduced before, for the ratio of V_1 and V_0. This is not to be considered as a demonstration of the equation, but only as showing how it may be regarded as being built up on the assumption that a condenser behaves towards alternating currents as an impedance, causing fall of potential in a current passing through it, and capable of nullifying inductance in a circuit connected in series with it; and that such a view leads to an equation from which it is immediately seen that under some conditions V_1 must be greater than V_0.

22. Reference has been made recently, in a paper read by Major Cardew, to the difference of electric condition as regards potential above the earth which will exist between two insulated conductors, one of which entirely encloses the other, and which have different capacities, when they are connected to the terminals of an insulated transformer or alternator. In the case of a concentric cable, the two copper members of which are insulated from each other, and the outer one insulated from a metallic sheath connected to earth, we have two insulated conductors, the interior one having capacity with reference to the outer, but not with reference to the earth, and the outer one having capacity both with reference to the inner and also with respect to the earth. This last capacity is generally, in cables as actually made, very much greater than the former.

In the case of the Ferranti trunk mains the inner-to-outer capacity is, as we have seen, about one-third of a microfarad per mile run of the cable. Calculating from the measured dimensions, and from the specific inductive capacity of the insulating material as deduced from the inner-to-outer capacity, the magnitude of the outer-to-earth capacity I find to be about 10 times greater, or more than three microfarads per mile. It follows immediately, from elementary principles, that the two insulated members of such a concentric cable will, when connected respectively to the terminals of an insulated transformer or dynamo, always be brought into such a condition that the outer member is at zero-potential as regards the earth, and that the full difference of potential which the transformer or dynamo is capable of making will subsist between the outer and inner member of the cable. This is true only when the outer member entirely encloses the inner member; but it is also true that when the two conductors have different capacities, by reason of position or form, there will be an electrical inequality between them, in that the difference of potential between each conductor and the earth will not be the same. The conductor which has the larger capacity will have the lesser potential with respect to the earth, provided always that both conductors attached to the poles of the generator or transformer are insulated throughout their length.

23. The condenser effect we have been considering, and in particular the alteration of the change ratio of a transformer which takes place when its secondary circuit is connected to a conductor system having a certain capacity in relation to the inductance of that secondary circuit, is found to operate in many curious ways in the practical use of such combinations. For instance, if a pair of alternators separately excited are working in parallel on an omnibus main leading to a conductor system of no sensible capacity, then we know very well that if the dynamos are synchronised, and contributing equally to the outgoing current, the method adopted to take one dynamo out of circuit would be to lower its exciting current, and when its outgoing current fell to zero to sever its connection with the omnibus main. If, however, the alternators are working through step-up transformers, and into a conductor system consisting of concentric cable, it is found by experience that the exciting current of the dynamo to be taken out must be raised, and not lowered, in order to bring it into a condition in which it can be cut off from the omnibus main without dangerous sparking at the switch; and, conversely, in putting it into parallel the incoming alternator has to be excited to a lower E.M.F. than is necessary to maintain the standard P.D. at the terminals of the step-up transformer before putting it into connection with the omnibus main. This is obviously due to the fact that the change ratio of the step-up transformer is altered by the very act of putting it into connection with the conductor system, and hence the excitation of the alternator at the moment of making or breaking connection with the main must be such as will bring the P.D. of the free secondary terminals of the step-up transformer to a value equal to the P.D. of the two points on the conductor having capacity to which they are about to be connected, or from which they have just been severed; and when the connection of the alternator is made, the excitation can be altered to divide the load on the machines properly. This, of course, would not be the case if high-tension alternators of very small inductance were set to work in parallel on such a concentric conductor system. In this case the condenser effect is practically nothing, and the behaviour of the machines on going into or out of parallel would present nothing unusual.

24. In the cases briefly discussed above, the cables, whether concentric or simple, have been found to act as single condensers substituted for them would act; and in the experiments described no progressive rise of pressure from one end to the other of a cable possessing capacity was found to exist.

It is, however, quite possible for self-induction, resistance, and capacity to be so combined together in one conductor that the action of an impressed periodic E.M.F. at one end will create a progressive rise of mean pressure along the cable when the far end is insulated. The complete theory of such effect is rather too long to discuss here. The propagation of a simple periodic current and the action of a simple periodic E.M.F. upon a concentric cable has been very fully discussed by Mr. Oliver Heaviside in an able series of papers on "The Self-Induction of Wires," published in the *Philosophical Magazine* for 1886 and 1887. A very brief summary of the results is all that can be given here; but those desirous of further information may be particularly referred to the *Philosophical Magazine*, vol. xxiii., January, 1887, page 18, in which paper Mr. Heaviside deals with the problem which is particularly the practical one—viz, a concentric cable having at one end a transmitting apparatus, such as a telephone, alternator, or a step-up transformer, and at the other a receiving instrument, such as another telephone or a step-down transformer.

We, have, then, a sending instrument having resistance and inductance; a cable having resistance, capacity, and inductance; and a receiver having also resistance and inductance. Given the E.M.F. in the transmitter, the problem is to find the current in the receiver.

Consider, first, a very long concentric cable having inductance, L, resistance, R, and capacity, C, all per unit of length. Fix attention upon a small length of the cable, δx, and suppose that the current flowing into this element at any instant is i, and the current flowing out of it is $i - \delta i$, when some E.M.F. acts at one end of the cable. Also, let v be the potential of the inner conductor at the one end of the element of length, δx, and $v - \delta v$ be the potential at the other end; then the current, i, at any instant, t, is determined from the fundamental equation,

$$\mathrm{L}\,\delta x\,\frac{d\,i}{d\,t} + \mathrm{R}\,\delta x\,i = \delta v\,. \quad . \quad . \quad . \qquad (33)$$

and the current and potential are connected by another relation,

$$\frac{d\,i}{d\,x} = \mathrm{C}\,\frac{d\,v}{d\,t} \quad . \quad . \quad . \quad . \quad . \qquad (34)$$

because the current flowing out of the element of length is less than the current flowing into the element by the condenser current taken up in the element.

Differentiating (34), and substituting in (33), we arrive easily at the equation,

$$\mathrm{L}\,\mathrm{C}\,\frac{d^2\,v}{d\,t^2} + \mathrm{R}\,\mathrm{C}\,\frac{d\,v}{d\,t} = \frac{d^2\,v}{d\,x^2} \quad . \quad . \quad . \qquad (35)$$

This differential equation gives us the means of determining the potential, v, at any time and place in the cable.

Let v_0 be the E.M.F. at the origin or the end of the cable at which the dynamo or the electromotor is applied, and let V_0 be its maximum value—such, that

$$v_0 = \mathrm{V}_0 \sin p\,t:$$

then, if the cable is infinite in length, the solution of the equation (35) can be obtained, and the potential, v, at any distance, x, from the origin, and any time, is easily shown to be given by

$$v = \mathrm{V}_0\,e^{-\mathrm{P}\,x} \sin\,(p\,t - \mathrm{Q}\,x),$$

where the quantities P and Q are

$$\mathrm{P} = \pm\left\{\frac{p\,\mathrm{C}}{2}\left(\sqrt{\mathrm{R}^2 + p^2\,\mathrm{L}^2} - \mathrm{L}\,p\right)\right\}^{\frac{1}{2}},$$

and $$\mathrm{Q} = \pm\left\{\frac{p\,\mathrm{C}}{2}\left(\sqrt{\mathrm{R}^2 + p^2\,\mathrm{L}^2} + \mathrm{L}\,p\right)\right\}^{\frac{1}{2}}$$

For the Ferranti trunk mains the values of these quantities have been calculated in section 14.

If the cable is not infinite in length, but has a finite length, l, then two cases may be considered—(i.) when the cable is short-circuited at the far end, and (ii.) when its two members are insulated or open-circuited at the far end.

Taking the first case of a concentric cable of length l, short-circuited at the far end, and attached to an alternator of negligible inductance and resistance at the other, Mr. Heaviside has shown how the potential at any distance, x, from the machine can be obtained, and also the current flowing through an ammeter placed at any point in the cable. If V_0 is the maximum value of the periodic E.M.F. applied at the dynamo end, and v is the potential at any time, t, and any distance, x, from the dynamo end, then he gives the value of v as

$$\begin{aligned} v = {} & \mathrm{V}_0\,e^{-\mathrm{P}x} \sin\,(p\,t - \mathrm{Q}\,x) \\ & + \mathrm{V}_0\,\frac{e^{\mathrm{P}x} \sin\,(p\,t + \theta_2 + \mathrm{Q}\,x)}{e^{\mathrm{P}l}(e^{\ \mathrm{P}\,l} + e^{-2\mathrm{P}l} - 2\cos 2\,\mathrm{Q}\,l)^{\frac{1}{2}}} \\ & - \mathrm{V}_0\,\frac{e^{-\mathrm{P}x} \sin\,(p\,t + \theta_2 - \mathrm{Q}\,x)}{e^{\mathrm{P}l}(e^{2\mathrm{P}l} + e^{-2\mathrm{P}l} - 2\cos 2\,\mathrm{Q}\,l)^{\frac{1}{2}}} \end{aligned}$$

(see *Phil. Mag.*, vol. xxii., September, 1886, p. 284).

It can be shown from the above that the ratio of the maximum value, V, of the potential at any distance, x, from the origin, to the potential at the origin, V_0, is given by the relation,

$$\left(\frac{\mathrm{V}}{\mathrm{V}_0}\right)^2 = \frac{e^{2\mathrm{P}(l-x)} + e^{-2\mathrm{P}(l-x)} - 2\cos 2\,\mathrm{Q}\,(l-x)}{e^{2\mathrm{P}l} + e^{-2\mathrm{P}l} - 2\cos 2\,\mathrm{Q}\,l} \qquad (36)$$

In the above equations P and Q stand for the functions of resistance, inductance, and capacity given above in section 14, and e is the Naperian base.

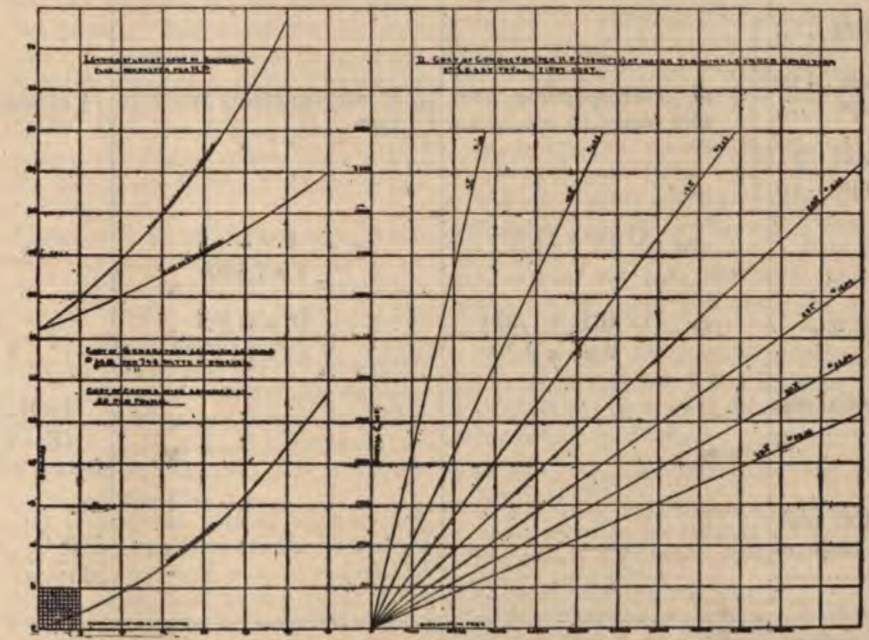
(To be continued.)

THE ELECTRICAL TRANSMISSION AND CONVERSION OF ENERGY FOR MINING OPERATIONS.*

BY H. WARD LEONARD.

(Concluded from page 533.)

In pushing engineering work, it is frequently of paramount importance that the work be done quickly. Therefore any means of greatly increasing the rate of drilling is extremely valuable. To increase the rate of drilling, we must either increase the strength of each blow or else we must increase the number of blows per minute. A limit to the rate of striking is soon reached when a valve of considerable weight must be moved from rest by the concussion of the previous blow, and when a material substance, such as air or steam, must then fill the space back of the piston and raise the pressure to the working pressure. Also the strains and shocks caused by the valve and the air or steam soon become troublesome as we increase the rate of striking. With the electric drill the speed of rotation of a perfectly balanced cylindrical armature of small diameter has no such limitations, and there is apparently no limit to the rate of striking, except the magnetising and demagnetising of iron, which is already done in daily commercial practice at the rate of 10,000 times per minute with the highest efficiency. With 800 blows per minute we have already drilled at the rate of 4in. per minute in a hole 1½in. in diameter in the hardest Quincy granite, and that with an expenditure of energy not exceeding 3 h.p.



CURVES OF LEAST TOTAL FIRST COST OF GENERATORS AND CONDUCTORS.

I firmly believe that in a comparatively short time we will be furnishing percussion drills whose rate of striking will be several times as much as that we now employ, and that with no more and no heavier drills than are now used, the rate of driving a heading will be increased many times. The importance of rapid driving of work is practically illustrated by the fact that in driving the Sutro Tunnel, Mr. Sutro offered the men at work, in addition to their regular wages, the following bonus:

For every foot per month over 300 and under 400	5dols.
For every foot per month over 400 and under 500	10dols.
For every foot per month over 500	20dols.

A recent bulletin from the Census Department shows that in granite quarrying the cost of labour is 84 per cent. of the total cost of production; and in Massachusetts, where the output is much greater than in any other state, and where the longest experience and most approved methods are met with, the labour is 82½ per cent. of the total cost. It will be evident that any labour-saving device in such a field will be extremely valuable.

THE ELECTRIC DIAMOND DRILL.

Another drill of great value to the mining engineer is the diamond drill. The Edison General Electric Company have, during the past 30 days, put upon the market an electric diamond drill which they have been developing for the past two years. The drill is the invention of I. E. Storey, of Denver. It presents a great many advantages over the diamond drills heretofore used, as will be evident from the following description:

The drill weighs complete 239lb. The average power consumed is about 1¾ h.p., and with this expenditure of power the drill will bore a hole of 1¼in. diameter in hard rock at the rate of 2in. per minute, taking out a core of ⅞in. The drill rod is rotated at the rate of 400 revolutions per minute without any load, and when drilling at full load the speed is practically the same. The drill rod is geared by a single set of gears to an electric motor, which revolves at 1,600 revolutions under conditions of full load. The motor has four poles, and the keeper joining the poles is in the shape of a surrounding cylindrical shell, which thoroughly protects all the parts of the motor and other parts of the machine. Upon the drill rod is placed a rotary pump which supplies the drill with the necessary water. In using the diamond drill the following points are of great importance: 1. The speed should be uniform and automatically controlled very closely, so that removing the load quickly will not permit the drill to run away. 2. The drill should be extremely steady, as any material vibration transmitted by the drill rod to the diamond points is disastrous to them. 3. The drill should run at as high a rate of speed as is consistent with smooth drilling and a proper supply of water. 4. The drill should be as light and compact as is consistent with the requisite strength. 5. The drill should be capable of being readily and rapidly moved considerable distances, and put into operation again with the least loss of time.

Up to the present time diamond drills are operated by reciprocating engines, and the engine is fastened upon same frame as the drill rod, to which it is geared by suitable gearing. The engine usually has two cylinders of the oscillating type to reduce the vibration as much as possible and eliminate the dead points. With these small engines it is practically impossible to automatically get the close regulation of speed which is desirable, and hence the speed is governed entirely by hand throttling, and the engines cannot be run at very high speed because of the vibration they would produce, and because of the rapid depreciation of such engines at high speed. It, therefore, becomes necessary to gear to the drill rod by gearing which is oftentimes objectionably larger, and would become even more so if a higher speed upon the drill rod were attempted, as is desirable. The space occupied by the drilling machine is quite as large, as the engine gears, and so forth, occupy much space. This is a great objection in cases of operation in tunnels, shafts, and so forth.

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* Paper read before the Association of Mining Engineers of Quebec.

TABLE I.—FORMULAS FOR ELECTRICAL DEVICES IN MULTIPLE ARC.

E = E.M.F. of generator in volts.
e = „ device „
C = Current in amperes.
c.p. = Candle-power of lamps at normal E.M.F.
T.c.p. = Total candle-power of lamps.
C.h.p. = Candle-power per electrical horse-power at normal E.M.F.
M = Area of cross-section of wire in circular mils.
D = Mean distance current is transmitted one way.
V = Loss of E.M.F. in conductor (in volts).
$ = Cost in dollars.
L = Cost of copper per pound in cents.
W = Watts per candle-power.
T = Weight of wire in pounds.
P = Efficiency of device.
p = Percentage loss in conductors.
G = Cost of generator per h.p. delivered by conductors.

CONDUCTORS, AS DETERMINED BY LOSSES THEREIN.

		—	Size.	Weight.	Cost.
Incandescent lamps.	2-wire system.	General cases ...	$M=\frac{T.c.p. \times D \times 16{,}000}{e \times V \times C.h.p.}$	$T=\frac{D^2 \times T.c.p.}{V \times e \times C.h.p. \times 1{,}000}$	$\$=\frac{D^2 \times T.c.p. \times L}{V \times e \times C.h.p. \times 1{,}000}$
			$M=\frac{T.c.p. \times D \times W \times 21{\cdot}5}{e \times V}$	$T=\frac{D^2 \times W \times T.c.p.}{V \times e \times 746{,}000}$	$\$=\frac{D^2 \times W \times T.c.p. \times L}{V \times e \times 746{,}000}$
		For 100-volt lamps, 4·66 watts per c.p.	$M=\frac{T.c.p. \times D}{V}$	$T=\frac{D^2 \times T.c.p.}{V \times 16{,}000{,}000}$	$\$=\frac{D^2 \times T.c.p. \times L}{V \times 16{,}000{,}000}$
		For 110-volt 3·1 watt lamps	$M=\frac{T.c.p. \times D \times 2}{3 \times V}$	$T=\frac{D^2 \times T.c.p.}{V \times 24{,}000{,}000}$	$\$=\frac{D^2 \times T.c.p. \times L}{V \times 24{,}000{,}000}$
	3-wire system.	General cases	$\frac{1}{4}$ of corresponding two-wire case	$\frac{1}{3}$ of corresponding two-wire case	$\frac{1}{3}$ of corresponding two-wire case.
		For 100-volt 4·66 watt lamps			
		For 110-volt 3·1 watt lamps			
For any case			$M=\frac{C \times D \times 21{\cdot}5}{V}$	$T=\frac{C \times D^2}{V \times 7{,}460}$	$\$=\frac{C \times D^2 \times L}{V \times 746{,}000}$
For power at motor pulley ...			$M=\frac{D \times H.P. \times 1{,}600}{V \times e \times P}$	$T=\frac{D^2 \times H.P.}{V \times e \times 10 \times P}$	$\$=\frac{D^2 \times H.P. \times L}{V \times e \times 1{,}000 \times P}$
For minimum total initial cost of plant			—	—	$\frac{G \times E \times V}{(E-V)^2}=\frac{G \times p \times 100}{(100-p)^2}=$ dollars per h.p. delivered by conductor.
Cost of generators for minimum total initial cost of plant			—	—	$\frac{100\ G}{100-p}=$ dollars per h.p. delivered by conductor.

With the electric drill the motion is free from any jar, as there are no reciprocating parts, and the speed can be made absolutely constant under any condition of load up to the full load. The speed of the drill rod can be made anything desired up to several thousand revolutions per minute if desired, and under any conditions of speed above 1,600 per minute there would be no gears whatever. The weight of the electric diamond drill is for the same power much less than that of the steam diamond drill, and the space occupied is in a direct line with the hole and is extremely small in amount.

The drill can be operated from any existing electric light circuit, and the current for it can be supplied at two miles distance from the source of power by wires of size 10 B.W.G. having a diameter of about ⅛in. The drill can be carried whenever a man can carry 35lb., which is the weight of the heaviest single piece, and hence can be set up and operated in the most inaccessible places.

It will be evident that for prospecting work, when a certain territory is to be explored, this drill is particularly adapted. Starting from a convenient and economical source of power, we can, if desirable, lay our wires along the surface of the ground, and in a very few hours can be operating our drill miles off. We can then reel up our wire and lay it again in an exactly opposite direction, and again be in operation at perhaps five or ten miles distant in the course of a few hours more. In laying the wire a couple of horses yoked abreast and carrying a reel are all that is necessary. For operating at a distance of one mile in any direction the diameter of the wire necessary is but $\frac{16}{10}$in., and the total weight of the wire only 340lb.

CONDUCTORS, AS DETERMINED BY SAFE HEATING.

Bare copper wire	15° C.	$M = C^{4/3} \times 200$
	35° C.	$M = C^{4/3} \times 170$
	45° C.	$M = C^{4/3} \times 100$
Average insulated copper wire	15° C.	$M = C^{4/3} \times 150$
	35° C.	$M = C^{4/3} \times 100$
Bare iron wire	45° C.	$M = C^{4/3} \times 328$
Bare German silver wire ...	45° C.	$M = C^{4/3} \times 608$

The facility with which prospecting and also drilling for permanent works, such as mines and quarries, can be done with this drill, will no doubt lead to its rapid and general use. There is every reason to expect that with the electric diamond drill the speed of rotation of the drill can be very greatly increased, with a consequent increase in the rate of drilling which will be of the greatest practical importance.

AN ELECTRIC DRILL FOR METAL WORK.

The Edison General Electric Company have a third kind of drill, which is a rotary high-speed drill, having a solid steel bit. This drill is used for drilling coal and similar comparatively soft materials, and also for drilling metals, where it will have an extensive use in the construction of steel ships, and bridges, and similar work in shop or field where the drill has to be taken to the work rather than the reverse. With the three drills which I have described, the Edison Company is now able to do any class of drilling desired, and these drills are likely to play an important part in the future of mining engineering.

OTHER APPLICATIONS OF ELECTRICITY TO MINING.

The electric mine locomotive, and the hoists, pumps, ventilating fans, crushers, stamps, etc., operated by electricity, are instances of the application of electricity to mining which have already proved themselves entirely successful. The under-cutting of coal by electricity is an important field in which the Edison Company has made great strides, the machines being of two entirely distinct types, in order to properly comply with the conditions met with in practice in different mines.

The electric refining of metals, especially of copper, is an extremely interesting subject to the mining engineer. The Edison Company has established the majority of the plants of this nature in the United States, and I need only say that the results are highly economical and most satisfactory in every way.

The electrical transmission and conversion of energy at great distances is destined to come up in nearly every mining problem in the future. Mines are usually in a mountainous country, and it is seldom that a water power cannot be found within a few miles of a mine. The mining engineer in the immediate future will develop this water power, convert its energy into electric energy, in which shape he will transmit it to the distant mine, when it will be again converted into the various forms of energy which he may have occasion to require.

Among the applications will be the following: (1) the lighting of the mines and the buildings and grounds by arc and incandescent lamps; (2) the operation of any machinery in the mill, such as crushers, stamps, and so forth; (3) the operation of the drills; (4) the operation of the hoists; (5) the operation of the pumps; (6) the operation of an electric tramway in the mine; (7) the operation of ventilating fans; (8) the heating of the buildings when fuel is scarce; (9) the refining of copper and recovery of gold and silver in certain cases; (10) the concentration of magnetic ores in certain cases, such as iron, nickel, and so forth.

In order to give you a commercial idea of a plant such as is likely to be used in mining operations in the immediate future, I will suppose a case and give you an estimate of the first cost and operating expenses of such a plant. Let us suppose that we have a mine where we have to operate the following devices: 360 incandescent lamps of 16 c.p. each; 10 arc lights; one hoist requiring 30 h.p.; one pump requiring 20 h.p.; six percussion drills for drilling $1\frac{1}{2}$in. holes at the rate of 3in. per minute; two rotary diamond drills, $1\frac{1}{4}$in. holes, $\frac{3}{4}$in. core, rate 2in. per minute; one mine locomotive, 10 h.p.; milling machinery requiring 30 h.p.; heating requiring 10 h.p.

The total power required for the above will be 180 h.p. delivered over the main motors. Suppose that at a distance of three miles there is a good water power which can be developed and equipped with waterwheels to produce 300 h.p. by an expenditure of 15,000dols. In considering transmission of the power by electricity we must first determine what loss we shall sustain in transmission, and then we must determine what electrical pressure we will operate with.

In designing such a plant there are certain fixed laws governing the conditions of highest economy and minimum first cost, and some years ago I investigated these questions and deduced formulæ expressing these laws.

These formulas are given in tabular form in the accompanying Table I. I have also expressed the laws governing the conditions of minimum initial cost graphically.

It may be interesting to note here in passing a fact which you will observe by examining the formulæ given—namely: If we pay proper attention to the laws governing the highest efficiency and the least first cost, the cost of the conductors for the plant will depend solely upon the initial E.M.F. and the distance. Thus, under practical conditions to-day, if we are to operate with 2,000 volts E.M.F. at a distance of five miles, the minimum first cost would be realised when we operate with a loss of 20 per cent. in conductors. The cost of copper (at 20 cents per pound) for each horse-power delivered at the motor brushes under those conditions would be 7.47dols. This simple but invariable law, which is embodied in the formulæ given herewith, you will find of great assistance to you in considering questions of electrical transmission.

You will also notice that the formulæ show that for any given percentage of loss the electrical pressure to be employed will vary directly with the distance. Thus, for 20 per cent. loss, the copper being 11.20dols. per horsepower delivered at motor brushes, the E.M.F. necessary for transmission of 16,000ft. will be 1,500 volts; at 32,000ft. we should use 3,000 volts, and at 8,000ft. 750 volts.

In order to secure the 160 h.p. necessary at our various devices in and about the mine, we must deliver 200 h.p. to our main motor in the form of electric energy in the conductor at the brushes of the motor. With 25 per cent. loss in conductors, this will mean 266 h.p. at the generator brushes, or 300 h.p. delivered by the waterwheels.

For the sake of reliability and economy we will use two generators instead of one, each being of 133 h.p. At the mine there will be two main motors of 90 h.p. each, wound for 900 volts and 83 amperes, producing a total of 180 h.p., which will drive the drill generator of 17 h.p. and a generator of 250 volts and 300 amperes for operating the incandescent lamps, the arc lamps, the locomotive, the hoist, the pump, the diamond drills, and the heaters. The main motors will also supply the milling machinery with the necessary 30 h.p.

By formulas in the table we find that to transmit 180 h.p. three miles with 25 per cent. loss and an initial pressure of 1,200 volts, there will be required a wire having a circular millage of 190,000 circular mils; that is, having a diameter of $\frac{436}{1000}$in. We find by other formulas in the table that the copper will weigh 20,000lb., and will cost 4,000dols., which results check each other and prove the accuracy of the calculation.

We are now able to make an estimate of cost of the plant for transmitting 180 h.p. a distance of three miles with a loss of 25 per cent. in conductors, and of the plant at the mine before specified:

Developing original water power and installing waterwheels of 300 h.p.	$15,000
Two generators, 100 kilowatts each (1,200 volts 83 amperes each), at 36dols. per kilowatt	7,200
Two motors, 75 kilowatts each (900 volts 83 amperes), at 36dols. per kilowatt	5,400
Copper, 32,000ft. No. 000 B.W.G.	4,000
One six-drill generator	2,000
One generator of 250 volts 300 amperes (75 kilowatts, at 36dols.)	2,700
Six electric percussion drills	3,300
Two electric diamond drills	1,100
360 incandescent lamps and appliances	360
10 arc lamps	220
One 30-kilowatt hoist	2,255
One 20-kilowatt pump	1,595
One 10-kilowatt locomotive	1,815
Heaters, 10-kilowatt	600
Conductors for all secondary transmissions	1,000
Labour of installation	3,000
Poles	455
Freight, cartage, and sundry expenses	1,000
Total	$53,000

The operating expenses of such a plant will be those mainly due to the wages of two men, one at the water power and one at the mine.

A fair allowance for depreciation and repairs will be 5 per cent. per annum of the first cost.

The operating expenses will therefore be about as follows:

One first operator	$900	per year.
One second operator	600	,,
Depreciation and repairs, 5 per cent. on 53,000dols.	2,650	,,
Sundry incidental expenses	250	,,
	$4,400	

The production of the same power by steam, when coal is 2dols. per ton, and labour such that an engineer's wages are

2dols. per day, would be not less than double this amount; and in many instances where water and fuel suitable for the generation of steam are difficult to obtain, such a plant would represent a saving of its entire first cost every year.

VOLTMETER AND CONTROLLING APPARATUS.

Only the smallest number of the voltmeters hitherto in practical use embody to more than the slightest extent the features that should be present in such an instrument. Almost all such apparatus require the use of factors that have to be applied to correct each reading; those containing a magnetic needle or permanent magnet need calibrating, or are not self-correcting for differences of temperature; and finally, a majority contain springs or changeable weights—all sources of error, as they may often be used by unskilled workmen, to whom most such apparatus is entrusted, when all certainty of the accuracy of the readings is lost.

Whoever has had the opportunity of comparing a large number of voltmeters of different construction, will have observed that the difference in the readings of those of the best makers frequently exceeds 5 per cent. As in an installation of incandescent lamps the potential of the lamps should be constant within 1 per cent., it is clear that such instruments are almost useless in practice. It should also be taken into consideration that a voltmeter which only gives the readings of the potential on a scale is of little use in industrial installations, as the operatives of the lighting plant can never leave it, because they must constantly have the little scale under their eyes.

It may therefore be properly required that every change of potential should give notice to the attendants by a clearly distinguished acoustic or optical signal. A Vienna firm, Messrs. Brückner, Ross, and Co., have constructed a voltmeter which embodies in a high degree all the features which should characterise such instruments. Its construction is the simplest imaginable. A circularly bent iron core swings from an axis, which moves in journals, and it is partly enclosed within the solenoid formed by a bobbin. This bobbin is wound with German silver wire, so that changes of temperature can be neglected. The attraction due to a current passing through the bobbin draws the core into the solenoid, exercising its attraction in opposition to the weight of the core. In consequence of judiciously selected proportions, the movement of the core is nearly proportional to the potential of the current.

To the axis is attached an index, which gives upon a scale the reading in volts, and also plays between two movable contact screws, and thus by changing the course of the current throws into circuit one or the other of two differently coloured incandescent lamps, or may start into action two differently sounding bells, so as to notify the attendants. For this purpose a branched current can go through the index.

The correct adjustment of the instrument follows from the fact that all variable weights and springs are omitted, so that even if taken apart by inexperienced hands, it can be put together again correctly, and will show the same readings as before. Changes of potential of 1 per cent. are shown by it with certainty.

PHYSICAL SOCIETY.—May 22.

Prof. W. E. AYRTON, F.R.S., President, in the chair.

Mr. F. H. Nevill was elected a member of the society.

Mr. C. J. Woodward exhibited Dr. Schobbens' form of lantern stereoscope. This instrument consists of a double lantern, by which the two pictures of a stereoscopic slide are projected on a screen. The two pictures are coloured complementary tints by placing pieces of red and green glass in front of the lenses, and each observer views the overlapping images through spectacles, the eyeglasses of which are also coloured red and green. The stereoscopic effect is very striking. **Mr. Boys** stated that he had tried to obtain a similar result with the aid of polarised light, by viewing two polarised images through Nicol's prisms. No effect was obtained owing to elliptic polarisation produced by the screen, but he thought that if a dead-gold screen had been used instead of an ordinary one, the effect might have been obtained.

Prof. Perry, F.R.S., showed a new form of steam engine indicator. A galvanometer mirror is fixed to a steel disc forming one side of a chamber filled with the steam under test. The pressure of the steam bulges out the disc, and causes the mirror to deflect a ray of light thrown on it in the ordinary way. A rotation at right angles to the former is imparted by the movement of the piston rod. The ray of light traces out the diagrams on a screen suitably placed, and the complete figure is continuously visible owing to the persistence of impressions. This indicator possesses advantages over other forms in being free from errors due to friction, or oscillations of the springs and the alteration of their elasticity due to temperature changes. The errors of ordinary indicators are considerable at high speeds, owing to the ripples introduced into the indicator diagram. If the natural period of the spring is one-twentieth of the time of a revolution, the diagram is fairly free from ripples; but if it is as much as one-tenth, no amount of friction in the indicator will prevent ripples forming. In the new indicator the natural period of the disc can be made very short. The steel discs are easily movable, and can be proportioned to suit different pressures and speeds. For experimental and teaching purposes it is advantageous to see at once the alterations in the diagram caused by changes of load, pressure, etc. Several diagrams were exhibited to the meeting. In reply to Mr. Carus Wilson, Prof. Perry stated that the deflection was proportional to the pressure in the cylinder within the limits any particular disc was intended for. **Mr. Addenbrooke** thought the instrument an important improvement on its predecessors, and considered it would prove of great service to electrical engineers. **Mr. Swinburne** said a peculiar merit of the indicator was that it could be permanently attached to an engine like an ordinary pressure gauge. He suggested the use of a small telescope instead of the ray method. The **President** thought that the instrument could be modified so as to be useful for analysing the shape of the curves representing alternating currents.

On "**Blakesley's Method of Measuring Power in Transformers,**" by **Prof. Perry, F.R.S.** This paper refers to the supposed error in Mr. Blakesley's formula due to the fact that transformers show magnetic leakage. The proofs of the formula hitherto given have been obtained by treating the equations in the manner first adopted by Dr. Hopkinson. On this system the reactions of the primary and secondary currents are represented by the equations

$$V = R_1 C_1 + P\frac{dN}{dt} \qquad 0 = R_2 C_2 + S\frac{dN}{dt}$$

where P and N are respectively the turns on the primary and secondary coils, and N is the magnetic flux between the coils. Here it is assumed that there is no magnetic leakage, and the author thinks that on this account the method is inferior to the original method of Maxwell, in which the induced E.M.F.'s are expressed in terms of coefficients of self and mutual induction. On the assumption that there are no eddy currents, Maxwell's equations are

$$V = R_1 C_1 + L_1 \dot{C}_1 + M \dot{C}_2; \quad 0 = R_2 C_2 + M \dot{C}_1 + L_2 \dot{C}_2;$$

in which, although L_1, M, and L_2 may not be constant, it may be assumed that they are respectively proportional to P^2, PS, and S^2, if there is no magnetic leakage; and if the amount of magnetic leakage bears a constant proportion to the whole flux, the three quantities may still be assumed proportional to each other, although M^2 is less than L_1, L_2. From these equations we obtain

$$V C = R_1 C_1^2 - R_2 \frac{M}{L_2} C_1 C_2 + \frac{L_1 L_2 - M^2}{L_2} C_1 \dot{C}_1.$$

Hopkinson puts down the last term as zero; but owing to the very rapid rate at which C_1 changes, the last term is very important, even though M may be but a small percentage less than $\sqrt{L_1, L_2}$. On integrating this equation, the first two terms on the right-hand side yield Blakesley's formula, and the last term vanishes in the integral; because, however great the magnetic leakage may be,

$$\int C_1 \dot{C}_1 \, dt = 0$$

when taken over a period, because the functions are periodic. Mr. Blakesley's formula thus appears to hold whatever the magnetic leakage. The paper contains several tables of calculations showing the effect of magnetic leakage or the value of the terms in the equation. **Mr. Blakesley** said he doubted the correctness of the assumption that the value of M was the same in the two equations, and thought that the result arrived at must be incorrect. **Dr. Sumpner** did not doubt that if the coefficients could be considered constant, the formula was true whatever the leakage, but he did not consider that the action of transformers justified such an assumption. If the formula were true, it would also hold if there were eddy currents, as these would merely produce the effect of additional secondary coils. He had analysed Blakesley's method by using a modification of the Hopkinson equations, and had shown that the power as estimated by Blakesley's formula had to be lessened by the fraction represented by the expression

$$X = \frac{\int x A_v \int A_s \, dt \, dt}{\epsilon + \int A_p A_s \, dt}$$

where A_p and A_s are the instantaneous values of the primary and secondary currents, and x is such that $N_p = N_s (1 + x)$ where N_p and N_s are the fluxes of magnetism through the primary and secondary coils at the same instant; ϵ is a negligibly small quantity compared with the rest of the denominator. In obtaining this factor no assumptions whatever had been made, and it was easy to see that if A_p and A_s could be assumed sine functions and x a constant, the value of the factor X became x simply. In only one case did X reduce to zero, and that was when x was a sine function of the same period as A_p and A_s. He believed that in actual transformers it was approximately constant. **Mr. Swinburne** pointed out that the split dynamometer was merely a wattmeter, and stated that he had transformers which, owing to magnetic leakage, would indicate an efficiency of over 100 per cent. if tested by Blakesley's method. If this method gives an efficiency of 96 per cent. and leakage causes a drop of 2 per cent. in E.M.F., the real efficiency is only about 94 per cent. He thought that the assumption that the currents followed a sine law was equivalent to supposing t [illegible] vas no loss in hysteresis. The **President** said that no o [illegible] a glad than himself to find that Mr. Blakesley's method was accurate, but he could not agree with Prof. Perry that Dr. Hopkinson was wrong in abandoning the academical method of Maxwell. **Prof. Perry** replied to the various points raised in this discussion.

A paper on "Current and Potential Difference Analogies in the Methods of Measuring Power," by Prof. W. E. Ayrton and Dr. Sumpner, was postponed.

LONDON COUNTY COUNCIL.

The Highways Committee reported to the meeting of the Council on June 2 as follows:

Provisional Orders, 1891.—That the Board of Trade has forwarded a copy of the City of London Electric Lighting (Brush) Order, 1891) in the form in which it has been granted, and that in this the amendment asked for by the Council has been inserted.

The Board of Trade has introduced a Bill into Parliament to confirm the Westminster, Islington, Wandsworth, Camberwell, Southwark, Woolwich, City of London (Brush), St. Luke's, Middlesex, Clerkenwell, and St. Luke's, Chelsea, Provisional Orders. They recommend that it be referred to the Parliamentary Committee to take any steps necessary with reference to this Bill.

North London Electric Supply Order, 1890.—They have had before them a letter from the Board of Trade, forwarding a copy of correspondence between the Board, the Vestry of Islington, and the undertakers under this order with reference to the non-compliance by the undertakers with the provisions of section 7 of the order requiring them to deposit the sum of £1,000, and to satisfy the Board that they are in a position to fulfil the duties and obligations imposed by the order. The Board states that, subject to any representations that the Council may make, it proposes to revoke the order. They have informed the Board of Trade that the Council has no observations to offer with reference to the proposed revocation of the order, and leaves the matter to be determined by the Board.

Notices under Electric Lighting Orders and Acts.—They have considered the undermentioned notices under the Electric Lighting Orders and Acts, and have, subject to the conditions stated below in each case, sanctioned on behalf of the Council the works referred to therein.

Notice, dated 4th May, 1891, from the Notting Hill Electric Lighting Company, of intention to lay mains on the south side of High-street, Notting Hill, from the corner of Campden-hill-road to 105, High-street. (Conditions: That the company do give two days' notice to the Council's chief engineer before commencing the work, that the cover-stones of the culvert shall not be less than 2in. thick, and that where the culvert crosses the carriageway there shall be at least 9in. thickness of Portland cement concrete above the cover-stones of the culvert in addition to the road material.)

Notice, dated 28th April, 1891, from the Electricity Supply Corporation, for the placing of mains in the subway in Charing Cross-road from the southern end to Cranbourne-street. [Permission had previously been given by the Council for the placing of this company's mains in the subway south of Green-street.] (Conditions: That the positions to be occupied by the mains in the subway shall be subject to the approval of the chief engineer of the Council, and that the work of placing them shall be carried out to his satisfaction. Formal notice has been given to the company to place the mains for Charing Cross-road, referred to in the notice dated 28th April, 1891, in the subway of that thoroughfare.)

Notice from the same company, dated 8th May, 1891, of intention to lay mains from a box in the carriageway of the Strand to the corner of, and along, Duncannon-street to Trafalgar-square. (Conditions: That the company do give two days' notice to the Council's chief engineer before the works are commenced; that the mains be laid under the footways wherever it is found practicable to do so; that the concrete floor of the road boxes be made 9in. thick; that the York stone at the top be 4in. thick; that the longitudinal girders in all the boxes be laid on 3in. stone templates the full thickness of the brickwork.) They recommend that the Council do ratify the action taken with reference to the matters above specified.

They have also to report the receipt of certain notices from the London Electric Supply Corporation, given in accordance with the resolution of the Council to accept four days' (instead of one month's) notice in respect of the laying of service lines from mains already laid—viz., to 181, 213, 229, and 235, Oxford-street; 5, Foubert's-place and 35, Haymarket; 22, Cockspur-street; 169, New Bond-street; 5, 6, 7, and 35, Haymarket.

Telephone Subways.—The National Telephone Company has applied for permission to use a space having a sectional area equal to one square foot, in the Council's subways in Charing Cross-road and Shaftesbury-avenue respectively, such space to be occupied by the company's cables. A similar request with reference to the Victoria-embankment and the Queen Victoria-street subways was granted by the Council on 24th March last, the company having agreed to pay rent in accordance with the scale recently adopted by the Council. The rent, according to this scale, in respect of the subways referred to in the present application, is £26 a year for each subway. The committee have, on behalf of the Council, acceded to this application, upon condition that the company enter into an agreement, to be prepared by the Council's solicitor, to pay a rent of £52 a year, being £26 in respect of each of the subways referred to in the application; that the positions to be occupied by the company's cables in the subways be approved by the chief engineer of the Council; that all cables and wires of the company now in the subway be removed into the space specified, and that all work connected with the subway shall be carried out to his satisfaction and at the cost of the company; and that proper earth connections be provided for the lead-covered cables.

LEGAL INTELLIGENCE.

HAMPTON AND SONS v. THE LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

Alleged Breach of Agreement.

This action came before the Lord Chief Justice of England and a London special jury on Thursday, May 28th.

The plaintiffs sued the defendants for £5,000 damages for their neglect to supply electric light to the extent of 600 lights to the plaintiffs' premises, situated in Pall-mall, in alleged breach of an agreement entered into between the parties at the end of the summer of 1888. There was a considerable conflict as to what was the actual contract (if any) to be derived from the correspondence which had passed between the parties, and as to what expenditure and loss of profits on the part of the plaintiffs could be in any way attributed to the defendants' failure to supply the light. It appeared that the plaintiffs made certain structural alterations in their premises so as to adapt them for the electric light, and also erected the necessary wires and other accessories, so as to meet the requirements of the defendant company. The defendants supplied converters, and appear to have turned on the current once, but never to have done anything further towards lighting the plaintiffs' premises. The plaintiffs were consequently put to great inconvenience, their premises being often left during the months of December to March in partial or complete darkness, and it was necessary to have recourse to less effectual means of lighting the several shops and showrooms. Evidence was given that, whereas the plaintiffs' sales for the four months in question in a previous year amounted to £54,998. 7s. 5½d., and in the succeeding year to £56,869. 2s. 0½d., in the year in question they only amounted to £36,041. 18s. 11d., and this decrease the plaintiffs largely, if not entirely, attributed to the gloom in which their premises were left. Ultimately the plaintiffs obtained a supply of light from the Metropolitan Electric Supply Company at a charge of 25s. a year per light, with the right to use as much light as they pleased during certain fixed hours of each day, whereas the defendants' charge was 7¼d. per unit, with the addition of a charge for meter, switches, etc., which, according to plaintiffs' view, would only have amounted to the cost of 12s. 6d. per light per annum. On behalf of the defendants it was contended that there was never any contract, and consequently that there was no liability at all upon them to supply the light, nor would there have been upon the plaintiffs to take it; and, further, that if the plaintiffs were in any way injured by the failure of the light the damages claimed were too remote for the defendants to be held liable for them. The defendants, whilst denying liability, had paid £75 into court as sufficient to satisfy any claim which the plaintiffs might have against them.

Mr. Jelf, Q.C., and Mr. Lee Roberts appeared for the plaintiffs; Mr. Moulton, Q.C., and Mr. Pyke for the defendants.

His **Lordship**, having summed up the case in great detail, left four questions to the jury—viz.: (1) Was there a contract? (2) If so, what was the contract? (3) Has the contract been broken? (4) And, if so, what damages ought the plaintiffs to recover?

The jury returned a verdict that there was a contract to supply electric current up to 600 lights on the terms contained in the application form, and gave the plaintiffs £175 damages beyond the amount paid into court.

His **Lordship**, having previously intimated what his own view of the case was, said that he would give judgment next morning.

On Friday his **Lordship** said that, as he had intimated during the course of the case, he was unable to see any contract at all between the parties, and, therefore, he must give judgment for the defendants with costs. The answers, however, of the jury to the questions he had put to them would be before the Court of Appeal, so that that Court would have all the necessary material for finally determining the questions in dispute. Execution upon the judgment would be stayed for a week, the appeal to be set down within that time; the money paid into court by the defendants to be paid out on the usual undertakings.

COMPANIES' MEETINGS.

NOTTING HILL ELECTRIC LIGHT COMPANY.

The annual general meeting of this Company was held on Saturday at the central station in Bulmer-place, Notting Hill, Prof. William Crookes, F.R.S., chairman, presiding. He said they had that day inaugurated a system of lighting which, he trusted, would go on continuously, night and day, for the parliamentary term of 42 years. They had purchased the freehold of Victoria-gardens, and the lease of seven small houses in Bulmer-place, adjoining the works, to avoid waste of time in the erection of the works, as considerable delay was occurring in consequence of injunctions obtained by the owners of the Bulmer-place property against the Company proceeding with its operations. The mains had been laid in the principal part of the compulsory area and comprised about three miles of culverts, and five miles of cable. Working as they did, on the three-wire system, they had thus laid about nine miles of copper strip, or a total of 14 miles conductor, containing altogether 67 tons of copper. It was proposed to extend at once to Westbourne-grove. An accumulator station was being arranged for Phillimore-mews, which would give them great facilities for supplying houses in their southern district. They were in treaty for a new site for the second central station near Addison-road, which the Directors had every reason to hope would be self-supporting from almost its commencement. The light had been supplied to a few houses experimentally for some weeks, during which time it had been subjected to careful tests as to steadiness and uniformity, and no fault had been detected, while not a single flaw or leakage had been found in their system of mains. For the present they expected to run entirely from batteries which would be charged a few hours a day, increasing as the load increased. He concluded by moving the adoption of the report and accounts. The motion was carried unanimously. The report and accounts will be found in our last issue.

CITY NOTES.

Eastern Telegraph Company.—The traffic receipts for May were £53,829, as against £53,373 for the same period of 1890, an increase of £456.

Direct Spanish Telegraph Company.—For the month of May the receipts show a decrease of £81 as compared with the corresponding period.

Brazilian Submarine Telegraph Company.—A quarterly interim dividend of 5s. per share, payable on the 24th inst., is notified by the Directors of this Company.

PROVISIONAL PATENTS, 1891.

MAY 25.

8830. **Improvements in the regulation and control of electric currents, particularly applicable to transformers, and in apparatus therefor.** John Augustine Kingdon, 29, Marlborough-hill, London.

8845. **Improvements in galvanic batteries.** Reginald Haddan, 18, Buckingham-street, Strand, London. (Isidoro Cabanges, France.)

8853. **Improvements in phonographs.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Béla Steiner, Hungary.)

MAY 26.

8872. **Improvements in galvanic batteries.** James Frederick Bennett and Ernest Parker Hydes, Bank-buildings, George-street, Sheffield.

8873. **Improvements in the construction of telephones, electric bells, and parts relating thereto.** James Frederick Bennett and Ernest Parker Hydes, Bank-buildings, George-street, Sheffield.

8874. **Improvements in telephones and electric bells.** James Frederick Bennett and Ernest Parker Hydes, Bank-buildings, George-street, Sheffield.

8876. **Improvements for recording or registering the time during which an electric current is in circuit.** Albert Hoster, 51, Cannon-street, London.

8892. **Improvements in dynamos.** Joseph Harrison Adams, 34, Fullerton-road, Wandsworth, London.

8896. **Improvements in means or apparatus for regulating or controlling the operation of machinery by electromotive power.** Reginald Bolton, 55, Chancery-lane, London.

8922. **Improvements in electric clocks.** Henry Smith Prentis, 23, Southampton-buildings, London. (Complete specification.)

8924. **Improvements in fuse blocks for electric circuits.** Henry Harris Lake, 45, Southampton-buildings, London. (Henry Sachs Kaliske, United States.) (Complete specification.)

8925. **Improvements in electric clocks, watches, or timepieces.** Christen Rees Bonne, 57, Chancery-lane, London. (The Société d'Horlogerie, Switzerland.)

8927. **Improvements in electromagnetic tools.** Wyndham Payne-Gallwey, William Stepney Rawson, and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

8932. **Improvements in electric locomotives or street car motors.** Henry Harris Lake, 45, Southampton-buildings, London. (Rudolf Eickemeyer, United States.) (Complete specification.)

8941. **Improvements in methods and apparatus for electrical hardening and tempering.** Alfred Julius Boult, 323, High Holborn, London. (Elias Elkan Ries, United States.) (Complete specification.)

8742. **Improvements in or relating to automatically and electrically stopping railway trains when within a predetermined distance of each other, or when the line is blocked by another train, or it is otherwise dangerous for a train to proceed, and in apparatus therefor.** William Phillips Thompson, 6, Lord-street, Liverpool. (Edward Deming, United States.) (Complete specification.)

8961. **An improved method of measuring electrical currents by expansion of fluid contained in hollow conductors heated by the currents.** Albert Campbell, 68, Patshull-road, Camden-road, London.

MAY 27.

8963. **Improvements in the method of wiring for electric lighting and other purposes.** William Brown Sisling, William Harding Scott, and Laurence, Scott, and Co., Limited, Gothic Works, King-street, Norwich.

8991. **An improved electric fire alarm.** George Bishop, 186, Fleet-street, London.

MAY 28.

9029. **Improvements in electric arc lamps.** William Arthur Turbane, 70, Market-street, Manchester. (Complete specification.)

9048. **The lighting by electricity of all vehicles drawn by horses, mules, and other animals.** Fredrick Cogan, Thomas Wright, and Richard Collins, 202, Kennington Park-road, London.

9073. **Improvements in electric railways.** James Ferguson Munsie, 45, Southampton-buildings, London. (Complete specification.)

9079. **Improvements relating to the electrolytic extraction of metals and to the electrolysis of other substances.** Carl Hoepfner, 45, Southampton-buildings, London.

MAY 29.

9103. **Improvements in dynamo-electric machines and motors.** James Swinburne, Broom Hall Works, Teddington.

9104. **Improvements in the manufacture of electric light carbons.** Ernest William Harvey and Charles William Alldred, 39, Alderbrook-road, Balham, London.

9107. **A connecting union for electric light fittings.** George Henry Barnes, 31, Warestone-lane, Birmingham.

9135. **Improvements in electrical apparatus for preventing railway accidents.** Wilhelm Ratzer and Sigmund L. Beer, 323, High Holborn, London.

9145. **Improvements in electrical measuring instruments.** Henry Capel Lofft Holden, Bernard Mervyn Drake, and John Marshall Gorham, The Cottage, Erith.

SPECIFICATIONS PUBLISHED.

1887.

701. **Electrical meters.** De Ferranti. (Second edition.) 8d.

1890.

7219. **Electric supply meter.** Perry. 8d.

8394. **Primary batteries.** Wright. 6d.

9257. **Electrolytic deposit with aluminium.** Wohle. 4d.

9904. **Electrical armatures.** Clarke. 8d.

10316. **Electric safety fuses.** Andrews. 6d.

10741. **Electric glow lamps.** Siemens Bros. and Co., Limited (Siemens and Halske). 6d.

10742. **Electric glow lamps.** Siemens Bros. and Co., Limited (Siemens and Halske). 4d.

10743. **Electrical conductors.** Siemens Bros. and Co., Limited (Siemens and Halske). 8d.

10806. **Electrical distribution.** Mills (Greenfield). 1s. 1d.

11051. **Armoured electric conductors.** Andrews. 8d.

20821. **Transferring electric car batteries.** Corning. 8d.

1891.

248. **Transferring electric car batteries.** Corning. 8d.

1969. **Electrical signalling apparatus.** Lake (Burrell). 8d.

1987. **Electric lamps.** Clark (Easton). 8d.

3331. **Secondary batteries.** Currie. 8d.

3449. **Telephones.** Rabbidge. 6d.

3799. **Charging electric batteries.** Clark. 4d.

3895. **Transferring electric car batteries.** Corning. 8d.

4259. **Electric motors.** Lake (The Giant Electric Motor Company). 6d.

4792. **Electric typewriters.** Silkman. 1s. 1d.

5252. **Electric railway signal apparatus.** Graff. 1s 1d.

5983. **Electrolysis.** Le Sueur. 8d.

6003. **Electrical conductors.** Reilly. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	1¼
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9¼
London Electric Supply	5	2½
Swan United	3½	4½
St. James'	—	6½
National Telephone	5	4¾
Electric Construction	10	
Westminster Electric		

NOTES.

Central London Railway.—The Bill for this railway was read a second time in the House of Lords on Tuesday.

Prof. Forbes has been amongst those who attended the American Institute of Electrical Engineers at the end of May.

Bicester (Oxon.) seems to be a town interesting itself in the electric light, and worthy some attention from electrical engineers.

Royal Meteorological Society.—The offices and library of this society are removed from 30 to 22, Great George-street, Westminster.

Kidderminster. — The electric lighting order for Kidderminster has passed through the House of Commons, and is unopposed in the House of Lords.

Photography.—Captain Abney read a paper before the Photographic Society, 50, Great Russell-street, last Tuesday, on "Dark Room Illumination."

Conversazione.—The annual *conversazione* of the Society of Arts will take place on Wednesday next, June 17, at the South Kensington Museum.

Heckmondwike.—The order for Heckmondwike has been found to comply with Standing Orders, and there being no opposition the further progress will be purely formal.

Dewsbury.—The Bill promoted by the Corporation of Dewsbury for electric lighting, has been found to comply with the Standing Orders of the House of Commons.

Halifax.—The Electric Light Company, Limited, were accepted by the Halifax Town Council as tenants of the premises now occupied by the Salvation Army at the present rate.

St. Pancras.—The laying of mains by the St. Pancras Vestry in Hampstead-road, Euston-road, High-street, Camden Town, etc., has been approved by the London County Council.

British Association.—A sub-committee of the Lord Provost's Committee in Edinburgh are occupied in arrangements for inviting the attendance of the British Association to that town in 1892.

Barnet.—Several further communications from lighting firms having been received by the Barnet Local Board, the clerk has been asked to obtain more exact estimates to enable the committee to report.

Scarborough.—In the House of Commons on Tuesday a Bill confirming the Board of Trade provisional order, which gives power for the lighting of Scarborough by electricity, was read a third time.

Newport (Mon.).—One of the orders in the Bill before Parliament empowers the Newport (Mon.) Corporation to supply the borough with electricity. The Bill will in due course be reported to the House for third reading.

Franco-Danish Cable.—It is stated that the second Franco-Danish cable, which will render it possible to send a message from St. Petersburg to Calais in 10 minutes, will be laid during the latter half of the next month.

Bengal.—Great attention is being paid to the development of technical instruction and training in the Seebpore College, Bengal, and measures are being taken to increase the outfit of mechanical and physical testing apparatus.

Rechristening Aluminium.—The name "Alium" is proposed, and with some show of reason, by Mr. Oberlin Smith, instead of the denomination "aluminium," a name which, it is pointed out, is longer than that of any other element.

London County Council.—The Offices Committee's report, brought up at Tuesday's meeting of the Council, stated that the contract with Messrs. Crompton and Co. for electric light work at the central offices had been sealed.

German Electric Railways.—It is announced that a syndicate of Berlin capitalists proposes to construct an electric railway from Blakenburg to Thal, and that the necessary power will be obtained from the Blakenburg central station.

Tramways' Institute.—The annual meeting of the Tramways' Institute of Great Britain and Ireland is to be held on July 2, at 11 a.m., at the Westminster Palace Hotel. Electric traction will be one of the principal subjects to be discussed.

Admiralty Returns.—For the information of the Admiralty the shipping authorities have been directed to prepare a quarterly return of all war material, including electric appliances and torpedoes, shipped from the United Kingdom to foreign ports.

Queen Carola of Saxony had a narrow escape from lightning last week. A thunderstorm came on and a flash of lightning appears to have struck the carriage; the horses reared and would have bolted but for the courage of the coachman, who fortunately kept control.

Hull.—The Electric Lighting Committee of the Hull Corporation resolved last Wednesday to recommend the Council to empower the committee to at once take the necessary steps for laying down an installation of electric lighting at a cost not exceeding £22,000.

Lisburn (Ireland).—The Lisburn Town Commissioners invite tenders to light the town, either by electricity or gas, in accordance with specification which can be seen at the office of Mr. R. Young, town clerk, Railway-street, Lisburn, who will receive tenders up to 13th inst., at 12 noon.

Electric Works.—A very good opening for persons intending to set up electric works with small capital is advertised elsewhere in the shape of the works known as Quentin Matsys Forge, Lambeth, with engines, boilers, forges, and tools, with workshops and dwelling-house.

Damage by Lightning.—At the meeting of the Royal Meteorological Society, to be held at 25, Great George-street, Westminster, on Wednesday, the 17th inst., at 7 p.m., a paper will be read on "A Curious Case of Damage by Lightning," by Alfred Hands, F.R.Met.Soc.

German and French Finance.—It is announced by a Berlin financial paper that the Allgemeine Company, of Berlin, has purchased a large amount of stock in the Popp Compressed Air Company, of Paris, and has made an advance besides of some six million francs to this enterprise.

Rochester.—A considerable sale of plant, including dynamos and machinery, will be held by Mr. Chas. Levy, at Bath Yard, Rochester (Strood or Chatham Stations), on Tuesday, Wednesday, Thursday, and Friday next. Particulars from the auctioneer, Strood Hall, Rochester, Kent.

London County Council's Laboratory. — The London County Council have served a notice upon the Metropolitan Electric Supply Company for—what? To dig subways, take up mains, or put in better material? No, but to please supply them with a little current for use in testing.

Blackpool.—The borough surveyor is enquiring what arrangements can be made for the electrical firing of a gun in Blackpool at a fixed hour each day so as to indicate the correct Greenwich time. The public clocks vary so much, that an arrangement of this sort would certainly be very desirable.

Consett (Durham).—At the meeting of the Consett Local Board last week, the clerk (Mr. Welford) was instructed to write Messrs. Nicholson and Jennings, Newcastle, informing them that the Board would like an interview with them with a view of obtaining more information with regard to the electric light.

Whitby.—The opposition to the Bill confirming the provisional order of the Board of Trade relating to the electric lighting of the town of Whitby having been withdrawn, the Bill has been referred back from the committee presided over by Sir H. Stafford Northcote, and will come before the Committee on Unopposed Bills to-day (Friday).

Extinction of Fire.—The Society of Arts announce that the Fothergill prize of a gold medal or £20 is now offered for the best invention having for its object the prevention or extinction of fire in public buildings. The description, with drawing or models, should be in the hands of the secretary, John-street, Adelphi, by Dec. 31, 1891.

Harrogate.—The Bill promoted by the Corporation for lighting the centre of Harrogate passed the Committee of the House of Lords on Friday last, the opposition of the telephone company having been arranged. It is understood there are electric lighting supply companies ready to contract with the Corporation for the lighting of the part intended.

Electrical Storms in America.—More than half the United States was simultaneously visited by a heavy downfall of rain on June 3rd. The condition of the telegraph round Chicago has seldom been equalled. The worst electrical disturbance on record is reported from Milwaukee, telegraphic and telephonic communication being rendered almost impossible.

Electric Voting Machine.—M. Moreau, we learn, will shortly show at Brussels an electric voting machine. It has a series of electric buttons, above which are ranged the names of the various candidates. Pressing a button registers one vote on a numbered dial. This can be locked up until the voting is complete, rendering the tedious counting unnecessary.

Oil at Erith.—The Erith Local Board have resolved to continue the lighting of their district by oil lamps for another year for £1,004 a year. They have obtained an estimate from the gas company for 266 lamps at £1,276, and, including attendance, think they will make a saving by using oil of £300 to £350 a year. Electric lighting was not considered this time.

Books Received.—We have received "Telephones and their Construction and Fitting," by F. C. Alsopp (Spon), fully illustrated. Also "The Arithmetic of Electrical Measurements," with numerous examples fully worked, by W. R. P. Hobbs, head master of the Naval Torpedo School, Plymouth, revised edition (Thos. Murby, 3, Ludgate-circus-buildings).

Train Lighting.—Prof. Kohlrausch, who was engaged to make tests and experiments upon the railway between Cronstadt and Stuttgardt, concludes that the use of a dynamo on the train should be rejected, and that preference should be given to accumulators, and among the best arrangements of these, that of charging the batteries at certain stations along the route is to be preferred.

Electricity in Chemical Factories.—Under the supervision and partly under the designs of Mr. T. Parker, of the Electric Construction Corporation, experiments have been successfully made to utilise electricity in the production of phosphorous. The patents and experimental works have all been acquired by the Phosphorous Company, by whom the works will in future be carried on.

Telegraphing to Lighthouses.—Mr. M'Combie, the secretary of the Aberdeen Chamber of Commerce, intimated at the last meeting that the President of the Board of Trade was to receive a deputation on Friday, the 12th June, from the Associated Chambers on the subject of telegraphic and telephonic communication with lighthouses and lightships. We trust all who can will use their influence in this matter.

Munk Bretton.—A communication from Messrs. Nicholson and Jennings to the Munk Bretton Local Board, offering to supply electric plant at yearly rental, was the occasion of some hilarity, the number of public lamps being asked, and this number was—two. A similar communication had been received at the Dodworth Local Board, and the members seemed to think they were having fun poked at them.

The Wizard of Deptford.—The *Journal of Gas Lighting*, after giving a sketch description of the Deptford station, says: "It cannot be said of Mr. Ferranti that his ideas are narrow; and they are reputed to be carried out with thorough attention to detail. Evidently, Mr. Ferranti is a wonderful man, not merely in being able to do such marvellous work, but in having the power of making his directors believe in him."

Electric Boats.—The taste for electric boats is increasing. The Electric Power and Traction Company have recently disposed of several to private owners, and have others on order. A great demand is experienced for the electric boats for Henley Regatta, which takes place on July 7th to 9th. Charging stations are now located at Hampton, Chertsey, Staines, Windsor, Maidenhead, Henley, Reading, Shillingford, and Oxford.

Liverpool.—At the monthly meeting of the Liverpool City Council, held on the 3rd inst. at the Town Hall, the Mayor (Mr. J. B. Morgan) presiding, the Watch Committee brought forward a scale of charges for testing lines and mains recommended by them to be made under the Liverpool Electric Lighting Order 1889, and this schedule was passed by the Council without discussion on the motion of Mr. H. H. Hornby, the chairman of the Watch Committee.

Rastrick, (Yorks.).—At the meeting of the Rastrick Local Board the clerk read a letter from Messrs. Nicholson and Jennings, electrical engineers, asking the Board to consider the question of having the township lighted with electric light instead of gas, and giving the advantages to be derived therefrom. After a little discussion it was passed, on the motion of Messrs. Brown and Robinson, that the whole of the members of the Board be a special committee to see to the matter.

Dudley.—Alderman Bagott, in moving the adoption of the Streets and Gas Committee's report, at the last meeting of the Dudley Town Council, said he thought the time had come when the whole of the borough should be lighted all the year round. Now they were a county borough it would be a step in the right direction. The Corporation might approach the Dudley Gas Company with favourable results, for the electric light was now in neighbouring towns.

Canterbury.—Before the General Purposes Committee of the Canterbury Town Council, the town clerk reported that the electric lighting Bill had passed the Commons. There had been a very few small alterations made. They were not of any moment, mostly clerical corrections. It had still to go to the House of Lords and receive the Royal assent. The Mayor asked if they had power to transfer the order to a company if they felt disposed, to which the clerk replied in the affirmative.

An "Electric Witness."—On Tuesday a curious case of stealing came before the Poole police court, in which electricity played the part of detector and witness. The prosecutor missing several bottles of spirits, fitted up an electric apparatus, which signalled if certain bottles were removed from the shelves. A man named Hammett went in for a quart of beer, and while the manager's back was turned the signal rang. The prisoner left the shop, but was followed, and the bottle of gin was found on him. He was remanded.

Physical Society.—Before the Physical Society at South Kensington Science Schools, to-day (Friday), at 5 p.m., Prof. Ayrton and Dr. W. E. Sumpner will read a paper on "Alternate Currents and Potential Difference Analogies in the Method of Measuring Power." Prof. Oliver Lodge will read papers on "A Clock for Pointing Out the Earth's Orbital Motion in the Ether," and on "Some Experiments with Leyden Jars." Prof. W. E. Ayrton and Mr. Mather will read a paper on "The Construction of Non-Inductive Resistances."

Prizes at Owens College.—An essay prize of £10 on the technical applications of electricity was offered for award in the session of 1890-1 by Mr. W. Mather, M.P., and a prize of a similar sum is offered for award by Dr. Edward Hopkinson in the session 1891-2. The subject for the essay in the current session was recent progress in magnetism, and Mr. Mather's prize has been awarded to Bertram S. Giles, a student in the evening classes of the college. The competition is open to both day and evening students in the physics laboratories.

The First Telegraph.—An article on the "Early Days of the First Telegraph Line," by Mr. Stephen Vail, son of Alfred Vail, is to appear, learns the *Electrical World*, in the June number of the *New England Magazine*. The author's father, Alfred Vail, was associated with Prof. Morse in the first inventions in the field of telegraphy, and additional interest is lent to the article by the claims put forth by Mr. Vail in behalf of his father's alleged share in the perfecting and making of practical use the receiver and transmitter now adopted by all countries.

Royal Society.—At the annual meeting of the Royal Society the following gentlemen were elected Fellows: William Anderson, Prof. Frederick Orpen Bower, D.Sc., Sir John Conroy, M.A., Prof. Daniel John Cunningham, M.D., George Mercer Dawson, D.Sc., Edwin Bailey Elliott, M.A., Prof. Percy Faraday Frankland, B.Sc., Percy C. Gilchrist, William Dobinson Halliburton, M.D., Oliver Heaviside, John Edward Marr, M.A., Ludwig Mond, William Napier Shaw, M.A., Prof. Silvanus Phillips Thompson, D.Sc., and Captain Thomas Henry Tizard, R.N.

Aerial Bombshells.—Mr. Hiram Maxim—whose energies, switched off from electrical, have gone to projectile matters—has been lately conferring with Prof. Langley, whose interest in flying machines is well known. Says Mr. Maxim, according to a recent newspaper report, "If I can rise from the coast of France, sail through the air across the Channel, and drop half a ton of nitroglycerine upon an English city, I can revolutionise the world. And I believe I can do it if I live." It is curious how all inventions seem to revolve round the destruction of mankind and their cities.

Liverpool Electric Laboratory.—At the meeting of the Fire, Police, and Lighting Sub-Committee, held at the Municipal Offices, Liverpool, on the 1st inst., the city engineer further reported as to the assistants to the electric inspector, Mr. Yeaman, and suggested that Mr. T. H. Tarleton, of Waterloo, be permitted to remain in the electric laboratory of the city engineer's department as a pupil, during the pleasure of the committee. This was unanimously agreed to after Mr. Tarleton had been called before the committee. An item of £38, for further fittings and equipments to the laboratory, was then passed without discussion, and the committee proceeded to other business.

Electricity in Collieries.—Electricity, says the *Colliery Manager*, has again given a most satisfactory account of itself as a valuable adjunct to coal-mining plant. On the 25th of April a very large feeder of water broke away at one of the pits of the East Howle Colliery, Ferryhill. If it had not been for the good service rendered by the new electric plant, lately supplied by Messrs. Mercier, Corlett, and Co., of Wigan, one seam must have been drowned out. The pump ran for 82 hours, only stopping twice in 24 hours, and then for a few minutes only to change brushes. In that time, Mr. Henry Palmer, the manager of the colliery, informs us, it pumped 2,700,000 gallons, or equal to 12,000 tons of water.

Tramways in Calcutta.—The subject of the bad condition of the tramways, we learn from the *Indian Engineer*, is engaging the serious attention of the mercantile community in Calcutta. The chairman of the Municipality, in reply to a representation from a prominent merchant, laid before them an exhaustive report from the engineer of the Corporation on the subject of the faulty construction and the wretched maintenance of the existing lines. A sub committee have been appointed who have taken the matter up vigorously. The lines are being improved, but the progress is not rapid. The present might, we think, probably be a favourable time to draw the attention of the authorities to electric traction.

Utilising Water Power.—The town of Dover (U.S.) on the Salmon Falls River, on the division line of Maine and New Hampshire, has an interesting electric plant, according to accounts just to hand. The water power furnishes not only light and heat to the town itself, but to several distant towns as well. Power is also supplied for an electric street railway system seven miles long. The waterfall supplies a force of 500 h.p. Greenwood Springs, in California, is also kept in a blaze of light by electricity furnished by mean of water power. Mills, pumps, hoists, and tramways are run miles away from the original source of power. Pelton waterwheels are used and keep in constant running order all through the winter, even when encased in ice on the outside.

Telephone in the West.—Some interesting figures are given in a verbatim report of the chairman's speech at the recent meeting of the West of England Telephone Company with reference to the returns per mile of metallic wire on the trunk lines, which were not included in our report. He stated that in 1887 these amounted to £1·36 per mile; in 1888 to £1·96; in 1889 to £2·06; and in 1890 to £2·56. The percentage on the cost of the trunks, yielded by the receipts, after payment of royalties and all working expenses, was, in 1887, 1·44 per cent.; 1888, 2·15 per cent.; 1889, 1·99 per cent.; and in 1890, 2·90 per cent.; so that the company's trunk lines are now returning nearly 3 per cent. on the capital expended directly, apart from the indirect return.

Electricity in Surgery.—A work on the "Electric Illumination of the Bladder as a Means of Diagnosis of Obscure Diseases," by E. Hurry Fenwick, F.R.C.S., surgeon to St. Peter's and London Hospitals, lately published, is illustrative of the manner in which electricity is invading the medical profession. The book is in its second edition, which seems to prove that it is a valuable addition to surgical science. A work on "Electrolysis in Surgery," by W. E. Steavenson, M.D. Cantab, is another book dealing with an equally important application. We are sorry to learn, after we have written this note, that Dr. W. E. Steavenson has just died from a severe attack of influenza and bronchitis, at the comparatively early age of 41. His loss to electrical surgery will be keenly felt. He leaves a widow and one child.

Paddington.—The sanction of the London County Council has been given to the laying of mains in Edgware-road, Paddington-green, Harrow-road, Praed-street, etc., by the Metropolitan Electric Supply Company, upon condition that the company give two days' notice to the Council's chief engineer before commencing the works; that the mains be enclosed in iron pipes or efficient casing, and be laid under the footways wherever it is found practicable to do so; that, as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, the two insulated from each other as far as practicable; and that the outer cover, which shall consist of an iron frame filled in with material to suit the paving, shall be efficiently connected to earth.

Larne (Belfast).—At the meeting of the Larne Town Council on Friday, the clerk, having read the advertisement requesting tenders for the lighting of the town by electricity, stated that no further tenders had been received than that of Messrs. J. H. Gordon and Co., Pall-mall, London, which had been previously considered. It was moved and seconded: "That the tender of Messrs. Gordon and Co. to light the town, including the extended portion of the town, with 10 arc lamps of 1,200 c.p. each, and 49 incandescent lamps of 16 c.p. each, for the sum of £200 per annum, from 1st August to 30th April, be accepted." The motion was unanimously passed, the chairman of Commissioners signing the agreement form. Mr. Boucher, agent of Messrs. Gordon and Co., stated that they were at present making arrangements to give a display of electric lighting.

Historical Apparatus.—Besides a very interesting collection of books, including three copies of the (A.D. 1600) edition of "De Magnete" (one an autograph copy), and other books embodying earliest references and history of pioneer days, the loan collection of the New York Electric Club, recently held, contained some interesting early apparatus. There was the Davanport railway, lent by Mr. Pope; an alternate-current transformer, according to the label, made and operated by Edison in 1878, by means of a Wallace-Farmer dynamo, the secondary having been used with 20 platinum lamps in parallel, and part of Mr. W. J. Hammer's unique collection of incandescent lamps, which is so complete that it has often figured in legal cases. The whole collection was particularly fine, and it is suggested that it would be well if such a collection could be made the property of the institute, instead of belonging to various private individuals.

Shipley.—At the meeting of the Shipley Local Board last week, Mr. Hardaker moved that a committee be appointed to make the necessary enquiries as to the practicability or otherwise of lighting the public streets or main roads of the district with electricity. He said that the Board some months ago had been waited upon by a deputation from the Shipley Tradesmen's Association with a request that this matter might be considered by the Board. It was thought that it might be possible to obtain motive power in the district at a reasonable rate, not steam power, and he thought the Board would be justified at least in appointing a committee to consider the practicability of the scheme. The chairman, in putting the resolution, pointed out that in the Swiss villages water power was being utilised, with the result that the electric light was being satisfactorily applied to dwelling-houses. There could be no harm in a committee being appointed. The motion was carried and a committee appointed.

Electric Meter Competition.—The results of the electric meter competition at Paris have been published officially. The Aron and Elihu Thomson meters fulfilling all the conditions of the programme, have awarded between them the 10,000 francs offered to the inventor who should produce a perfectly satisfactory meter, applicable equally well to either alternate or direct currents. The instruments submitted by M. Frager and M. Marès having realised important improvements, three prizes of 1,000 francs have been awarded to these gentlemen—viz., to M. Frager (alternate current) 1,000 francs, to M. Frager (continuous current) 1,000 francs, to M. Marès (continuous current) 1,000 francs. We are told that the number of instruments was 51, submitted by 29 competitors. The experiments have been conducted at the municipal station at the Halles Centrales since December, 1890. The members of the jury nominated by the Municipal Council on November 20, 1890, were MM. Mascart, Pottier, Hospitalier, Cochin, and Lyon-Alemand.

Morley (Leeds).—At the meeting of the Morley Town Council last week the town clerk read communications with respect to supplying the borough with electric lighting, and remarked that more than one company had their eyes upon Morley, and if the Corporation did not take the matter up, the Board of Trade would give powers to one or more of those companies. The question that the Council would have to consider was whether they would allow another company to have the monopoly. In reply to a question, the town clerk said the gas company were trying to seek powers to supply electric lighting He suggested that the matter be referred to the Lighting Committee. In reply to a further question, the town clerk replied to the effect that the Board of Trade had power to grant outside companies permission unless the Corporation took action. After considerable discussion the matter was referred to a special committee.

Wigton.—At the monthly meeting of the Wigton Local Board, the discussion on electric lighting, which had been left over from the previous meeting, was resumed. During the discussion (in which a comparative statement was read, supplied by Messrs. Nicholson and Jennings, electricians, Newcastle-on-Tyne, who had submitted a scheme showing the relative cost of electricity and gas, in one instance the figures showing a balance of 50 per cent. in favour of the former). Mr. Rigg said he was rather surprised at these figures, as he understood that the cost was equal, even in a case where the dynamo was worked by water. Dr. Tiffen said that the system was not perfected yet, but it would come in time. Mr. Brown objected to the cost of its adoption, which, with a sum of £160 for redemption rental, along with £3 or £4 a week for working expenses, would make a total of £300 a year, which certainly they were not able to pay at present. This appeared to be the opinion of the majority of the members, and the question was left for the present.

Electric Launches. — Two new electric boats were launched on Monday from Messrs. Woodhouse and Rawson's Strand Electric Works, Chiswick. The larger of the two, the "Glowworm," has been specially designed for Mr. Pears, by Mr. W. S. Sargeant, manager of the launch works, who also designed the two electric launches, "Pioneer" and "Pilot," previously built for the same owner. The "Glowworm" is 53ft. long, with 7ft. 2in. beam, has a draught of 2ft. 6in., and displacement of

5¾ tons. She is built of bright mahogany with teak fittings, and has a cabin specially designed for this kind of launch amidships. The accumulators run underneath the seats throughout. The launch will carry 40 passengers, make about nine miles an hour, is lighted as well as propelled by electricity, and carries a search-light. The propeller rotates at the rate of 600 revolutions per minute. The "Glowworm" will be a prominent feature at Henley Regatta. The other boat, the "Myiomi," is 35ft. long, with 5ft. 6in. beam, and 18in. draught, and a displacement of 3¼ tons, and is built for Captain Homfray, of the Horse Guards. She is constructed of mild steel, with teak fittings; her electric arrangements are similar to those of the "Glowworm," but there is no search-light. She will be present at Henley Regatta, and is especially adapted for river work. Her speed will also be about nine miles an hour.

Soldiers Struck by Lightning.—At Berlin on Tuesday morning when a company of the Emperor Francis Joseph Regiment of Grenadier Guards was drilling on the Tempelhof field a severe thunderstorm came on. They had just finished their task of digging a ditch when a tremendous peal rent the air, and the lightning struck the middle of the company. A great number of soldiers were rendered insensible, and fell to the ground. Captain Von Quast's horse, veiled in a cloud of smoke, reared and fell dead. A soldier who was holding the bridle was dangerously wounded. The lightning had struck his helmet, and made a wound in the back of his head the size of a five shilling piece. His clothes and the right side of his body were singed, and from the wound on his head to his neck the hair was burnt clean off. The left side of his back is covered with burns and marks left by the lightning, and he is also badly marked from the neck to the left side of the breast. This lightning tatoo was of rather a reddish than a bluish hue, and was in the form of fir branches, with the points turned downwards. The captain, with seven soldiers, who lay insensible on the ground, were all taken to a neighbouring hospital, where they soon recovered, with the exception of the one who remained in a dangerous condition. About 25 other men complain of headaches, burning on different parts of the body (no wounds, however, being perceptible), and of twitching and pricking in the muscles and joints.

New System of Submarine Telephone Cables.—The perfection of the transmission of speech through telephonic cables depends, as we know, for long distances upon the value of the product of the capacity, K, of the cable by the electric resistance, R. When this product does not exceed 10,000, the line is good. M. Picou, according to the *Bulletin Internationale*, in order to arrive at a satisfactory result has proposed the following arrangement. The conducting portion of the cable would be divided into two parts, all along the whole length. That is to say, there would be two conductors of copper of a half-moon section, separated by a dielectric, and both enveloped within the same insulating material. The transmitter would be connected to one of the extremities of one conductor; the other extremity would remain free. The second conductor at the extremity adjacent to the free end of the first would lead to the receiving instrument; the other end of this remaining free, as with the first one. The receiver and transmitter would be connected direct to earth. The cable being submerged, the whole will form a condenser, and a telephonic line would be obtained presenting all the qualities advantageous to it from the point of view of clearness of transmission. The idea, we think, merits consideration and deserves the attention of those who are engaged on the present telephonic cable work, as also from those sanguine electricians who hope for the possibility of transmitting spoken words across the Atlantic.

Business in the North.—Messrs. Ernest Scott and Mountain, Limited, Close Works, Newcastle-on-Tyne, have, we understand, secured the contract for the lighting of the Bolton Technical School, the installation to consist of two of their approved type Tyne compound-wound dynamos, with fast and loose pulleys and heavy turned flywheels, each machine being capable of running, if required, up to 200 16-c.p. lamps. The installation itself will consist of 220 16-c.p. lamps, with fittings. The firm have also the contract in hand for the lighting of the Armagh Spinning Company's mills in Armagh, Ireland; the installation consisting of one Tyne compound-wound dynamo for 400 16-c.p. lamps and 380 incandescent lamps, and fittings. They are also lighting Mr. Walter Jones's house at Blakemere, Cheshire, throughout; this installation will be very complete, the motive power consisting of a horizontal steam engine and boiler, with automatic expansion gear and Tyne dynamo for 90 16-c.p. lamps, accumulators for 80 lamps and 110 lamps throughout the house, stables, etc. The same firm are lighting Messrs. Edwards's dry docks at South Shields, the installation which they are now erecting being specially designed to enable the repairs of oil ships to be carried out with safety, it not being possible to use oil lamps in holds where petroleum vapour exists, on account of the risk of explosion. In addition to the above work, we understand that Messrs. Ernest Scott and Mountain, Limited, are extremely busy in their electrical department, having just completed a large hotel in Huddersfield, and also have in hand three large installations in progress in Scotland.

Eastbourne.—At the meeting of the Eastbourne Town Council last week, Councillor Strange, pursuant to notice, moved the following resolution: "That the Lighting and General Purposes Committee be requested to report on the best means of lighting the borough either by electricity or oil, and to take such steps as they consider necessary to obtain the best information." He said he was not then advocating the lighting of the borough either by oil or electricity; he simply urged that they should possess themselves of such information as would enable them to ascertain the most efficient and economical system of public lighting. The vagaries of the present gas meters were simply extraordinary. Meters were supposed to register the same, or nearly the same, and yet he found them registering from 1s. 9d. to £2. 10s. 7d., though the latter were no doubt connected with the Suggs lamps. This discrepancy in the consumption of the street lamps was very unsatisfactory. In suggesting enquiry into the practicability of lighting the town by oil, it might be said they were going back a decade; but oil lamps were much improved, and were being largely used. When they heard that the authorities of a fashionable resort like West Cowes had unanimously resolved to do away with gas, and light by oil, it proved there was something in oil lighting. The 1,002 gas lamps at Eastbourne, at £4. 4s. 6d. a lamp, cost £4,200 odd. The total cost of the same number of oil lamps, including the expense of cleaning, repairing, and trimming, was £2,254 (about £2. 5s. a lamp), the difference between the cost of the two illuminants being, therefore, very considerable. In addition to the relative cheapness of oil, its illuminating power was greater than gas. Councillor Wenham seconded, remarking that it was their duty to make enquiries. At the same time he should never be a party to any retrograde movement in regard to lighting They must have light of the best, and plenty of it, but he was convinced they were paying too much for their gas. The motion was carried.

REMINISCENCES OF THE FIRST ATLANTIC CABLE.

We have many times urged the necessity both from the point of view of historical accuracy and of general interest to the present generation, on the part of those interested in cable literature, of endeavouring to carefully gather all the personal experiences possible from those, now all too few, who were actually engaged in the laying of the first Atlantic telegraph cable. Many of those from whom valuable and interesting particulars could have been obtained have passed away, and the knowledge they had of this exciting and important event in the history of the world's progress is for ever lost.

We have been fortunate enough to obtain the acquaintance of a gentleman, Mr. Robert J. Lecky, who of all others is most able to afford some interesting side lights upon the undertaking, both in its inception, in its first and unsuccessful attempt in 1857, and in its more successful outcome in 1858. Mr. Lecky, whose name will bring up many pleasant recollections to those who were engaged upon this enterprise, was, at the time the first cable was laid, an engineer, residing at Valencia Island, manager to the Valencia Slate Slab Company, and also a practising engineer on his own account. He was one of the few gentlemen on the island who took a scientific interest in the operations of the surveyors, telegraph clerks, and the officers of the ships who laid the cable, and much help and hospitality they obtained through his aid. In all its stages he was a most interested spectator, and his reminiscences naturally include some interesting material.

It may be well to prefix Mr. Lecky's account by a simple *résumé* of the state of affairs at Valencia. This island, now so well known in connection with the cable, is a small rocky isle just off the extreme west coast of Ireland, its position with regard to the mainland making a harbour of the straits between the two, on the coast of the island on the inner side being a collection of buildings dignified by the name of Knights Town. These comprised the works of the Slate Slab Company, the coast guard station, Mr. Lecky's house, the hotel, and some boarding-houses and workmen's dwellings. It was in the coast guard station, and afterwards in one of the rooms of the Slate Company's works, that the receiving office of the cable company was established. The works contained two large engines, with lathes and other machines; the slate quarries being on the side of the mountain three miles away, 400ft. above the level of the ocean.

We give the following account as taken down from Mr. Lecky's lips, and practically exactly in his own words.

"As I mentioned," said Mr. Lecky, "I was living, at the time of the laying of the first Atlantic telegraph cable, at Valencia, a civil engineer on my own account, and with command of my own time, and, besides my private practice, was in management of the Valencia Slate Quarries. Being resident on the island, I was present at many of the early operations, and was naturally greatly interested in the laying of the cable. The first event that occurred to draw our attention to the work was the arrival in the harbour of H.M.S. 'Cyclops,' commanded by Captain Dayman, reckoned the first naval surveyor in the Navy, who was sent over by the Government to take soundings from Ireland to Newfoundland. He had with him Admiral Washington's son—Admiral Washington being the head of the Naval Surveying Department—and two or three other first-rate men in the Navy. This was in the early summer of 1857. I went on board the 'Cyclops,' and learned all about their mission. The 'Cyclops' went away, took the soundings, and afterwards returned to Valencia.

"The next event was the arrival of Cyrus Field, who came over himself to settle at what place the cable should be landed. I found him a man of enormous energy and ability, devoted to the success of the cable. He came quite by himself and wandered about the island and along the coast, and finally fixed upon the place called Trabaun, or the White Strand—a low white shore on the mainland opposite, and a little north of the island—a great contrast to the bold headland of Doulus Head, into which the coast soon changes, from whence the Atlantic Ocean stretches away to Newfoundland. It is interesting to remark that so little was known of the habits of Atlantic cables that it was thought necessary to dig out a deep pit and sheer it with strong timber baulks in order to anchor the shore end of the cable, not realising that the clinging of sand and mud on the shore end would be anchor enough.

"Cyrus Field was a man of utmost promptness of action and depth of resource. Although the event belongs to a later stage of the cable, it may be well to relate as an instance how in 1865 he came down one day to his office in New York and received a letter to say they could not raise sufficient funds in England. He sent up at once to his house for his portmanteau (which he kept always ready packed), and, without stopping to say good-bye to his wife, he took the steamer that sailed that same morning and came straight to England. He went at once to a gentleman, a very old friend of my own, whom he consulted, and they decided to go to John Horatio Lloyd, a very celebrated barrister of that day, best known in the railway world. This consultation resulted in the starting of the 6 per cent. preferred shares — which we still see quoted on 'Change every day — of the original Anglo-American Telegraph Company, which were to bear double the interest of the ordinary shares up to and not over 6 per cent.—still a good investment.

"However, this was the later, the 1866, cable. To return to the first one.

"Very soon after Cyrus Field's visit of inspection the workmen arrived, and the land line was laid to Killarney from the White Strand. A corrugated iron house was put up to protect the telegraph clerks and the line watchmen; but it must be noted that, practically, messages were never received at this hut from America, but across the straits again to the Island of Valencia, where were the works, houses, and hotel, and what other accommodation was to be found in this part of the country.

"The next occurrence was the arrival of the ships bearing in their holds the first (1857) cable. The cable was made in two halves, and stored in two ships—the 'Niagara,' an American vessel, and H.M.S. 'Agamemnon.' These were accompanied by two smaller vessels as companions—the 'Susquehanna' and the 'Leopard'—and there were also a number of smaller boats and a steam tug. The 'Niagara' came first and landed the heavy shore end of the cable on the 6th of August, 1857. The end was paid out on to the fleet of small boats, and the tug drew the whole flotilla with the gradually uncoiling shore end, which was landed and taken into the iron hut, the event being the occasion of a banquet given by the Knight of Kerry. The 'Agamemnon' had also arrived, and the two ships, with their two companions, steamed off to sea—the proposed method being to lay the first half, join up in mid-ocean, and continue the laying from the other ship to the other coast. It was not till afterwards that the laying was accomplished from the centre to the coasts in both directions. When the ships had sailed, I went up the mountains next morning and could see the masts of the steamers just above the horizon. A guttapercha-covered copper line was laid across from the hut at Trabaun to Knights Town and into the coast guard station, where the first instruments were placed. These were needle instruments with a strong steel needle that made a good click which could be heard all over the office. James Phillips (the father of James Phillips, of Johnson and Phillips) was clerk there at the time, and another man —I cannot remember his name at the moment—from Silvertown. I remember seeing the relays, and the instruments ticking away in the window. They ticked away there the whole day—two, three, days. Then it stopped suddenly, and we knew all was over.

"The scheme was a failure: before they had got more than 270 miles* from Valencia the cable broke and fell overboard, and they were obliged to abandon it. They had no methods in those days for picking up the cable. It was, moreover, a very slight cable compared to those now laid. It was only about ½in. across, containing a tiny strand of copper—seven strands of about 24 gauge thickly covered with guttapercha, and slightly armoured with numerous strands of thin iron wire. I carry a piece of it mounted as a charm on my watch chain, and I have some 18in. or so of it, with a quarter of a mile or so of the land line, as well as the original Thomson reflecting galvanometer, the commutator, and the scale, which came into my possession after the failure of the second laying.

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* Mr. Lecky's recollection is that this distance was about 53 miles, but the above figure is taken from the very interesting map compiled by the late Lieutenant-General (then Captain) Brine, R.E., published by Stamford's, Charing Cross, for half-a-guinea, on which a large amount of information relative to the laying of the 1857 and 1866 cables, with dates, figures, and positions of ships, is incorporated.

"The ships returned with the cable, or, rather, the 'Agamemnon' returned with her half, accompanied by her companion the 'Leopard,' and the 'Niagara' and the 'Susquehanna' went on to America. The 'Agamemnon' went into Plymouth, and the cable which was stored in her was taken out and coiled up again and stored—rather a foolish proceeding, as it was determined to attempt the laying again next year. The other half of the cable was, I believe, not taken out of the 'Niagara.'

"I remember calling in Plymouth, and meeting Sir Charles Bright, and Sir Charles Canning, and Captain Kell, in April, 1858, when they were again shipping the cable on board the 'Agamemnon.' The 'Niagara' also just happened to arrive with her half of the cable. I remember it was an occasion when I had some business in Cornwall, the last mail coach journey I ever had in England. Crossing in the ferry boat, I passed under the stern of the 'Niagara,' which had just arrived in Plymouth. Coming back to Plymouth we spent a very pleasant Sunday together, and went for a drive in an open carriage in the afternoon.

"I did not see them start, but I learnt that the two boats started together to mid-ocean. Here they joined the two ends of the cables. The 'Niagara' went to Newfoundland and the 'Agamemnon' returned again to Valencia. This time, as we all know, they were more successful. I was in London at the time, and occasionally dropped in at the offices of the Atlantic Cable Company, Old Broad-street, to hear if there were news. Before returning to Valencia, therefore, I called in and asked the clerk how they were getting along. 'Yes, he thought they were going on all right.' 'Not any news, I suppose, yet?' 'Oh, yes; he thought there was some news.' 'You don't mean they have landed yet, do you?' 'Oh, yes, Sir,' he coolly remarked; 'yes, they had landed.' 'What! and received messages from America?' 'Oh, yes, Sir; yes—messages have been sent.' He was most cool about it, as if it were a matter of everyday importance. But I—I was greatly excited. I rushed off to John Lloyd's offices in the Temple. He, it may be stated, had an interest to the extent of a thousand pounds in the cable. I walked in, trying also to be cool. He was in, but terrible busy. 'I am very sorry, but I am really too busy to-day,' he said; 'you must excuse me.' 'I—have—something to say,' I said deliberately. 'What? what?' he said, half expecting some news. 'THE CABLE IS LANDED AT VALENCIA, AND IS WORKING TO NEWFOUNDLAND.' He jumped up. 'Huzzay! Huzzay!' he shouted, and threw up his hat for joy at the event.

"The next day I returned to Valencia and found the cable working. An interesting point is that the two ships landed their different ends almost simultaneously, within a few hours or so of each other, communication having been kept, of course, between the two ships. The Slate Slab Company had, as I have said, a large building—stores and shops—at Knights Town, and this I was instructed to put at the service of the cable company. It was in this house that the messages from America were received. It was a long building with machinery and stores on the ground floor, and above this the long room was partitioned off as sleeping and living rooms for the telegraph clerks. The building was some little distance from the sea, and the guttapercha wire was led up and buried in the ground in the yard and so up to the building, where it ended in the end room of the gable. The receiving-room was about 25ft. long by 12ft. wide. There was not a great deal of apparatus about the place—one of Sir Wm. Thomson's reflecting galvanometers, a commutator nailed against the wall, an oil lamp, and Holzaffel scale pinned against the wall, upon which the dot of light made dashes and dots in the telegraphic alphabet.

"The battery was an enormous affair. There were a long set of troughs, with plates, a foot square, of silver and zinc. The silver plates were of pure metal, and cost somewhere about £200, I believe. In fact, it was a stupendous battery, and it was said, indeed (I do not know with what truth), that it was the battery that burnt the cable, and so soon caused it to fail. There was besides, I remember, an enormous induction coil—two great coils wound (very badly) on two great bars of iron, some six inches diameter and eight feet long! Looked at in the light of present experience, these enormous batteries and coils were ridiculously out of place; but the fact was, that nobody knew at all what was wanted. They were all at sea. They had, I fancy, no means of measuring the current—no means at any rate of measuring the resistance to any degree to be compared with present practice. The thing was new, wonderful; and they were all far too much novices to understand the proper conditions of working. I have since been told that Latimer Clark borrowed a thimble from Miss Fitzgerald, and filling this with nitric acid, sent a message across the later cable by this simple means which was received and acknowledged.

"I never actually saw a message received with my own eyes, and there were not a great many messages sent, other than a few formal ones of congratulation by the Queen, some Government messages, a few Press messages and test messages for the cable. There were, I believe, no really paid messages sent at all. It is curious to remember that at the time, as was perhaps only natural, great incredulity was expressed as to whether any message really had been delivered or not. I well remember a friend of mine at Cork, a very self-opinionated man, to whom I had been speaking of the cable, who growled, 'There never had been a message by that cable—and never would be.' I told him that there had been one day a message, that two ships had been in collision off Cape Race, Newfoundland, and some days afterwards, when the post came in, this was confirmed, and he had no more to say.

"Even during the time the cable was working it saved, as many persons may have heard, the Government of England tens of thousands of pounds sterling. There happened to be a regiment in Canada under orders to sail for the East Indies, at the time of the Indian Mutiny, when news came of the suppression of the mutiny and the regiment was stopped by cable message.

"I remember at the time some excitement was aroused at the telegraph station by the arrival of Dr. Hamel, then generally known as the 'Russian spy,' who came over to examine and report for the Russian Government. He had a general commission to gather all sorts of industrial information and forward it to Russia. He was not at all in good repute with the telegraph men, and I was obliged to act the part of kind friend to him. Everyone in the station knew him and hated him. He used to frequent the hotel and pretend to be asleep on the sofa to hear what was going on, but when they discovered who he was they used to turn the talk upon the Crimean War and Sebastopol, and finally by their remarks induced him to awake and decamp.

"The cable went on transmitting messages for about 10 days after I had returned to Valencia—a period of about a fortnight altogether—and then one day it ceased also. No more messages would come. The cable was a failure. They could not discover the cause, or what the failure was, and they had no means of calculating by tests, as they can now, exactly whereabouts the break or the fault could be found. Captain Kell came to Valencia and tried to pick up the cable in one of the local sloops to examine it. But the bottom for some 100 miles or so off Valencia was a rocky, jagged bottom, and the cable had apparently got caught or jammed on the rocks. They recovered a little of the cable (some of which I now have) and the shore end. Captain Kell tried his best to pick up the cable further out, but no power he had in command would stir it. The effort was therefore abandoned, and the hut was dismantled; the instruments were taken down, and the material sold for what they would fetch, and I took possession of the instruments. A clerk was left in charge for some months. A house had been fitted up for the cable engineer, Mr. Bartholomew, who afterwards died in Cyprus, but this was never used, and matters soon resumed their ordinary appearance.

"These are my reminiscences of the first Atlantic cable. I left Valencia before the laying of the 1866 cable."

ELECTRIC TRACTION.

V.—SURFACE LINES.

By far the greater proportion of existing locomotive traffic will be found of course to fall under the head of surface lines. Not only do æsthetic and sanitary reasons account for this, but economy of construction is also a decisive characteristic of such systems.

Traction along surface lines, or tram and rail ways laid on the ground level, is, speaking generally, of two chief kinds: it may either involve the moving of heavy goods and materials such as are necessary for the due fulfilment of our civilised needs; or, secondly, of human beings, people, passengers, who are desirous of being transferred or carried over distances without much bodily exertion.

It is principally with lines built to fulfil the latter purpose that this section will deal; for although there are already electric tram or rail ways in existence upon which heavy goods have for some time been successfully and economically transported over considerable distances, yet the present developments of electricity as employed for tractive purposes appear mainly to be in the direction of passenger traffic upon our city and interurban lines.

Probably for a long time to come our heavy goods and mineral trains will be worked by steam locomotives; it is more especially in the development of rapid transit passenger lines (where there is a frequent service of light trains) that electric traction will find a special opening.

Speaking generally, there are two great classes of surface railways for passenger use, depending respectively upon the average speeds employed. These may be placed at, say, seven miles per hour for street tram lines in towns and outlying districts, and from 25 to 30 miles per hour in the case of railways, where the lines are enclosed from public entry, where the stopping places are fixed, and at considerable distances apart, and where a fairly high speed is necessary in order to get over the ground.

Taking these in the order named, it will be found in connection with ordinary tramway lines (such as would be included under the first-named class of surface line for passenger use) that in practice any one of the various methods of operating the line already mentioned (see article III.) may be employed with more or less advantage and benefit.

Thus, in the most crowded streets and along roads where there is a considerable amount of heavy traffic, already existing lines for horse cars might be utilised at once without further alteration for the purposes of electric traction by means of accumulator or secondary battery cars.

No great additions in this case would be necessary to capital expenditure on account of the permanent way; whilst the saving of horse space and the more convenient handling of cars would prove most important benefits in working the line.

Further away from the centre of the city or town, on roads or routes where traffic is lighter and space not so valuable, the question of more economical working will claim attention, and the continuous conductor systems will offer superior advantages.

Thus, either the insulated third rail on the ground level may be employed in one form or another—though it is not by any means the most satisfactory excepting under very special conditions—or preferably the conduit method can be used with particular advantage.

In the most recent and best forms of the latter plan, the conduit under the street or road level (in which runs the continuous conductor) is so devised and built that the groove of one rail is made to serve as the continuous slot by means of which the travelling contact arm fixed to the car obtains connection with the continuous conductor that is placed in the conduit leading away to the central power supply station.

There are, therefore, no more than the usual two rail grooves in the street pavement for each line; an important matter when there is a large amount of traffic, by reason of possible danger to other vehicles whose wheel tyres occasionally skid across or into the rail grooves.

On still less-frequented suburban roads, and in country districts, there should be no objection whatever to the employment of what is, after all, the most cheaply erected and economically worked of these conductor systems—viz., the overhead method.

In this method, as with the use of storage batteries, no alterations are required for the permanent way of a good standard well-built tram line. The overhead conductors are easily erected on ornamental ironwork poles, which cannot by any stretch of imaginative astheticism be deemed ugly or out of place, whilst at the same time they positively fulfil an excellent purpose in serving also as possible supports for electric lights or public lamps.

Moreover, because the conductor wire is 18ft. or 20ft. from the ground, and, therefore, quite out of possible reach by the ignorant or mischievous, it becomes an easy matter to work the line at a high electric pressure, thereby obtaining very great economy in operating expenses.

The loss of current by leakage from the conductor would also be much less in this case, as the best types of insulation may be used between conductors and supports.

The plan usually adopted is to erect a row or series of ornamental iron poles, about 120ft. apart, along the centre of the roadway between the two pairs of rails. Near the top of each pole is fixed a cross-arm and supporting bracket carrying at each end an insulator arrangement, from which is hung the conductor wire.

Simple and cheap as this method undoubtedly proves, both to erect and maintain, yet it will of course be seen at once that its scope is limited—at least in England—to lines along unfrequented roads, or in thickly-populated districts where the traffic is mainly of a "through" character, and where no likelihood exists that the overhead wires at an altitude of some 20ft., or so, will be found inconvenient or troublesome to public desires or requirements.

But a method of this kind, unsuitable as it is to ordinary town tramway traffic, becomes at once and essentially the only possible means of working higher speed railway traffic successfully.

To compete favourably against the steam locomotive, electric traction must involve no great outlay on the road itself; the plans adopted must be such as are cheaply carried out and economically worked.

These advantages are most of all to be obtained from the use of an overhead conductor system; and an additional point that will without doubt enter largely into the schemes of high-speed electric railways for light passenger traffic is the fact that by combining the insulated overhead conductor with the ordinary rails a sort of strong framework (making the conductor into a third rail, fixed overhead) the trains will run supported throughout by the two rails as usual underneath, but will be steadied in addition by the third or overhead rail or conductor.

With these three points of supports it should be an extremely difficult matter for any train to become derailed, if not actually impossible; and the speed of travel could be very greatly increased with considerable advantage and perfect safety.

(To be continued.)

BOILERS AT THE ROYAL NAVAL EXHIBITION.

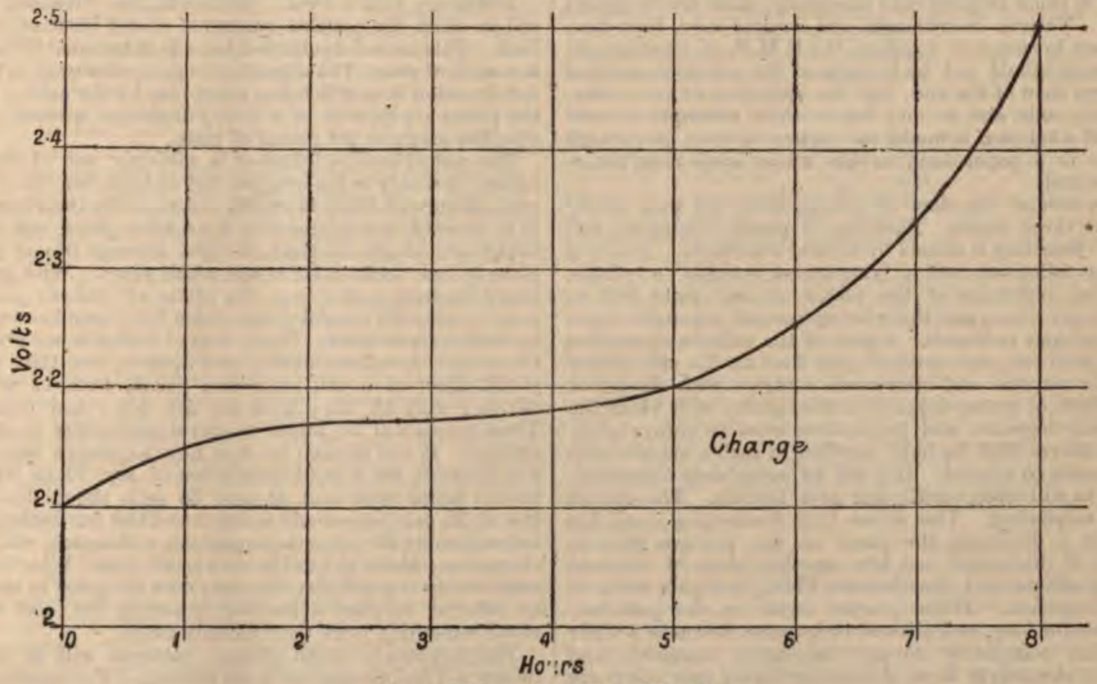
Messrs. Davey, Paxman, and Co., engineers, of Colchester, who supplied the whole of the motive power for driving the electric light machinery at the great International Fisheries, Health, Inventions, also the Colonial and Indian Exhibitions respectively, recently held in London, and at the Royal Military Exhibition last year, are supplying the whole of the steam boilers at the Royal Naval Exhibition, now being held at Chelsea. The boilers are 10 in number, of the locomotive type, each made to work at 140lb. steam pressure, and are tested by hydraulic pressure to 250lb. per square inch. Each boiler contains 710 square feet of heating surface, and 19·16 square feet of grate surface. The boilers are of steel and made in the best possible manner. The plates are all planed or turned on the edges, and the rivet holes drilled in position. The flanging is done by special hydraulic machinery of the most modern construction. The inside firebox is made of Davey, Paxman, and Co.'s well-known mild steel, and each plate is carefully annealed after having passed through the various machines. The rivets used in the construction of the boilers are of steel, and of special quality. The boilers are provided with all necessary fittings and mountings of first-class quality. Instead of the usual mudhole doors and bridges, the boilers are fitted with a novel form of metallic joint, recently patented by Mr. Paxman, which is a very neat and excellent form of joint, especially for high-pressure boilers. Across the entire width of the boilers runs a steel receiver, into which each boiler discharges its steam. The receiver is made up in lengths of 6ft. 6in., and these, with their flanges, are welded together in one piece, and makes a very excellent specimen of good work. It will be noticed that by this system Davey, Paxman, and Co. have a very convenient arrangement for enabling them to open or shut down any boiler or boilers, as may be required, at a moment's notice. The boilers are placed as follows: One battery of eight in the electric light shed, and a further battery of two in the Camperdown Gallery, thus making 10 in all. The boilers are fed by two of A. G. Mumford's celebrated "duplex" steam pumps, and, in addition, each boiler is fitted with an injector. It will be seen from the above details that every care has been taken and provision made to ensure the efficient working of the whole installation, and reflects great credit on the makers. The exhibition authorities have done wisely in selecting so good a firm to supply and superintend the boiler arrangements.

ELECTRICAL STORAGE BATTERIES.*

BY H. B. VORLEY, A.I.E.E.

(*Concluded from page 551.*)

Having touched upon the chemical side of the storage cell, it may be well to commence on the electrical. When a cell is fully charged, it will give off for a short time a current at the extraordinary high voltage for a battery of 2·25 volts, but while discharging will gradually run down to 1·8 volts. The diagram shows a 31 L plate cell, and at that voltage it will discharge its various number of ampere-hours. The voltage of the cell should never be allowed to run down lower than 1·8 volts or the cells will suffer. In order to charge a cell, therefore, we must use an E.M.F. of 2 volts in order to overcome the 1·8 of the cell. But as the voltage in the cell itself rises, it becomes necessary to charge with a higher E.M.F., and consequently when the voltage of the cell is 2 volts the charging E.M.F. must be 2·5 volts. This is one of the reasons why it is so necessary to charge secondary cells with a shunt-wound dynamo, because with a machine of this description, within certain limits, when the resistance of the circuit increases, the E.M.F. rises, whereas in series-wound machines, when the resistance increases the E.M.F. falls, and in compound-wound machines remains the same. The counter E.M.F. of the cell forms a sort of resistance which, of course, rises as the charge goes on, and consequently it is necessary that the E.M.F. of the dynamo should rise as the charge continues. The other reason why a shunt machine is used is because of the danger of reversals. If the current from a storage battery finds its way back into a dynamo which is not running, it starts it up as a motor. Now in the cases of series or compound-wound machines, the current from the cells must necessarily traverse the field magnet in the reverse direction, and therefore change the polarity of the machine. In a shunt-wound dynamo, however, the current from the cells would traverse the fields in the same direction, and cannot reverse the polarity of the machine. In order to avoid storage cells ever discharging back into a dynamo, and running it as a motor, a magnetic cut-out is always used, so that when the dynamo stops running the cut-out falls off, and the circuit is broken. Automatic devices are also made, by which the cells are made to cut themselves into charge as soon as the dynamo starts up again.



Curve of Rise of E.M.F. on Charging.

The current with which a cell should be charged varies according to several authorities, but according to the Electric Construction Corporation's tests it should be about 5·3 amperes per square foot of positive plate. In the L type of plate, for example, the plates being not quite a foot square, in a cell containing 15 plates, the charging amperes should be from 30 to 35, while in a cell containing 31 plates from 65 to 70 amperes. If the charging current is less than this, of course it will take longer to charge the cell, whereas if the charging current be too great the extra current will only be wasted, and will unduly heat the electrolyte and injure the plates.

The current which should be discharged by a cell should be at the rate of 6·1 amperes per square foot of positive plates. Sir D. Salomons says: "For a 15-plate E.P.S. cell, 28 amperes should be the maximum current for discharge; in a 23-plate cell, 44 amperes; and a 31-plate cell 60 amperes. A slow discharge from a cell can do no harm whatever, but a sudden discharge is apt to buckle the plates, and the paste falls out. If a cell be discharged too heavily till its gravity falls below 1·100, and its voltage below 1·8 volts, layers of sulphate form on the plates and do an immense amount of harm, about which more hereafter.

The capacity of a cell for discharging will be seen when it is stated that a 15-plate cell discharges 300 ampere-hours, and a 31 L plate cell 669. The efficiency of storage batteries is a matter which has been very much disputed. The real secret depends on the treatment they receive. A battery which has lost none of its active material, and which is charged with the exact amount of current for the chemical union to take place and no more, so that there is no waste, will, when discharged at a very, very slow rate, yield over 90 per cent. However, this is a very uncommon thing to take place, and cannot be said to occur anywhere else than in laboratories. Treating a battery generously, so that the cell is charged till it has been evolving gas for some time and discharging at not too slow a rate, the efficiency will be 75 per cent. The usual efficiency of cells is generally considered to be between 60 and 70 per cent. If a cell is allowed to rest some little time after a discharge, it will be found to have recouped its strength a little. It is, therefore, a good plan to charge intermittently, allowing short periods for the cell to rest now and again.

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* Paper read before the Junior Engineering Society.

The actual electrical resistance of a cell is really very low, the apparent resistance being, as before explained, the counter E.M.F. of the cell. The virtual internal resistance, of course, differs according to the specific gravity of the electrolyte, condition of plates, and other things, but it is always higher when discharged than charged, owing, of course, to the electrolyte containing more H_2SO_4. During a healthy discharge a very common internal resistance is ·0012 of an ohm.

Weight plays a very important part in a storage cell. Lead is necessarily very heavy, and the endeavour is always to get a maximum surface of plate for a minimum of weight. The E.P.S. 18-plate cell weighs 130lb., including acid, whilst the 31 L plate weighs 236lb., so that it will be seen that each plate weighs between 5lb. and 6lb.

There are three ways of ascertaining the condition as to charge of a cell. Firstly, by observing the voltage ; secondly, the specific gravity ; and, thirdly, by observing the voltage of the dynamo while charging the cell, the latter being in the opinion of the author the most reliable. The voltage of a cell is very deceptive. When half or even threequarters discharged, on open circuit or through the voltmeter circuit, it will show very often over two volts, and is therefore unreliable. The specific gravity method is better, but is still unreliable, for by mixing acid and water to the same density, and pouring into, say, a dozen cells, and then charging these cells with the same current, you will rarely find two densities alike. Then, as the cell depreciates, it will take a great deal of extra current to bring the electrolyte up to its original density. So that specific gravity, although giving a general indication as to the condition of a cell, will not afford an accurate gauge of the charge therein. The third and most reliable method is by observing the voltage of the dynamo charging. This must be accurate, and must be slightly above the actual counter E.M.F. of the cell, and as the E.M.F. of the cell varies must rise or fall accordingly.

Storage cells are, as a rule, charged in series, but may be discharged either in series or parallel. If in parallel, of course, they will discharge enormous currents, but at an E.M.F. of only two volts, so that for most purposes, especially lighting or traction, they are coupled in series, in groups of 25 or 30 or 50, according to the voltages of the lamps or motors. If, for instance, 50-volt lamps are used, a group or groups of 25 cells in series are used. If there be more than one group, these can be placed in parallel. Various instruments and devices have, from time to time, been invented to regulate the E.M.F. of a battery, so that the lamps should not be brighter at the commencement of the discharge than at the end, also for switching in extra cells, and opposing cells, and so on ; but as their description could very well fill a volume, it would be useless to even go through their names in a paper such as this, whose scope must necessarily be limited.

There are several disorders of storage cells, but they chiefly come under three heads. Buckling of plates, sulphating, and reversing. Buckling is caused by several conditions. If any of the paste has fallen out, and is lying across between two plates, the electrical resistance of the plates at that point will be less than at any other, and there being unequal expansion there will be a tendency to buckle. Again, if the cells be charged or discharged with too great currents, the heat in the cells causes the plates to expand and afterwards contract with disastrous results. Much of course depends on the rigidity with which the grids are held together, and precautions must be always taken that the positives shall be held together in such a manner that they have room to expand. If a cell be completely exhausted, the negatives will often buckle and give trouble. The second disorder is sulphating. This arises from discharging a cell too low. After a discharge the paste on the positive plate is $PbSO_4$, but if discharged too low, another atom of sulphate joins the positives and they become $PbSO_5$, a higher form of sulphate altogether. White powder forms on the positives, and if left on for long, and allowed to increase, becomes a white paste, which completely covers the active material, and prevents the electrolyte from circulating freely into the pores of the minium. In a mild form sulphating can be cured by charging long and continuously, when the powder will fall to the bottom of the cell, but nearly always carrying with it some of the paste, and thereby lowering the efficiency of the cell. If the coating of sulphate has covered the plates they must be scaled—that is, taken out of the acid, and the coating removed. Mr. Barber-Starkey claims that by pouring a little carbonate of soda into the cells, sulphating is nearly avoided, and certainly an addition staves the danger off very considerably, especially if it so happens that the cells have to be left alone for a lengthened period without receiving charge. The third disorder mentioned is the outcome of general neglect. If the plates of a cell be allowed to become short-circuited by bits of paste falling between the plates, the cell will, of course, hardly absorb any current, and will consequently run down very low. The result will be that the next cell in series with it will discharge itself into the ill-conditioned cell and reverse its polarity. The signs of this will be observed in the negative plates all beginning to turn red, especially near the top. Of urse, if this were allowed to run on, the plates would be completely reversed, to their ultimate ruination, but it must be checked in time, the only cure being to disconnect it altogether during discharge, and charge it long and continuously in the right direction until the right polarity is once more established. Negatives, if exposed to the air for long, are apt to blister, so that care ought to be taken, in erecting the cells, that the plates are immersed in the liquid as soon after unpacking as possible. The chief difficulty to be contended with in the manufacture of pasted plates has always been to prevent the active material from falling out, and the Patent Office is full of ideas for keeping the paste in. Some years ago the E.P.S. Company tried the experiment of building their plate up in two halves and making the cavity to receive the material barrel shaped. They found, however, that this method was not successful, as the plates did not adhere together, but broke apart, expanded unequally, the plates buckled, the paste fell out, so that the method defeated itself. A method was also tried by Hochhausen of cutting V grooves horizontally in a solid lead plate and filling up the groove with the paste. In the present cell manufactured by the Electric Construction Corporation, it will be observed that the square hole is decidedly undercut so as to form a hollow for the paste.

In the plate of Mr. Reckenzaun the paste is rolled up into small cylinders about 1in. long and $\frac{3}{16}$in. thick and allowed to harden. A number of these cylinders are placed in rows, and the lead grid cast round them.

The Crompton-Howell plate is made of soft, spongy lead, formed on the Planté principle. The plates are much thicker than those of the Electric Construction Corporation, the advantages claimed being additional strength and freedom from buckling. The plates are made of a special kind of porous lead, and are set in separators made of celluloid, and are kept apart at the top by celluloid combs. Corrugated and perforated sheets have also been used as separators. Very large cells of this type have been manufactured containing 61 plates, some of these weighing nearly threequarters of a ton, and capable of discharging 1,000 amperes each, and are now in actual use at the central station at Kensington-court. The gravity of the electrolyte when the cell is charged is kept at 1·240, which falls to 1·220 when the cell is discharged.

Lithanode Cells.—Prof. FitzGerald has invented a storage cell in which the positive consists of a solid block of peroxide of lead. This material solidified he calls lithanode. The negative is a stick of zinc. The objection to zinc, of course, is that when not in action it is still being eaten into by the acid. However, the plates are capable of a heavy discharge without damage—viz., five amperes per pound of plate.

The cost of storage batteries is certainly one of their drawbacks ; not only is the original cost so high, but the expense in connection with them is greatly enhanced by their depreciation. It is generally considered that a negative plate will last practically any length of time, but the average life of a positive plate is from three to three and a half years. With sudden and heavy discharges, of course, the plates will fall to pieces much sooner, but with careful usage plates have been known to stand for five years or more. The prices of batteries are pretty much the same. A cell containing seven plates, size 11in. by $13\frac{1}{4}$in., is £1. 11s.; of a cell same size plates, with 11 in number, £2. 4s.; with 15, £3 ; with 23, £4. 10s.; and with 31, £6. These prices will be found to correspond pretty much with all makers. It will be seen by this how expensive batteries are. For instance, for a small installation of, say, 70 or 80 lamps, if 50-volt lamps were used, at least 25 cells should be used, and this at £6 per piece would amount to £150 for batteries alone, not reckoning for cut-outs, ammeters, voltmeters, etc., and cost of erection, which in itself is not a small item. What is urgently need to-day is a cell that will cut down the price in the market, an efficient cell, but a thoroughly strong one, and which will stand something more than delicate usage.

The purposes to which storage batteries will be put in the future will be pre-eminently for lighting. For traction in trams and trains it is not the opinion of the author that they will ever find a place, although they are used with some slight success for electric launches ; the vibration even there is not calculated to improve the plates, while it may be confidently asserted that in the cases of trams and trains no cell has been found yet which will stand the wear and tear of the roads. They have found their place among the plant of many an electric light installation. As a reserve when machinery is at rest, as regulators when running, they ensure that the consumer is never left in the dark, and in cases of breakdowns in machinery they are indispensable. Buildings have been known to have been lighted for five or six days by storage batteries, when it has so happened that there has been a breakdown in the machinery, while for temporary lighting, for concerts, balls, etc., they form a convenient method of installing, at a short notice, the electric light, while dispensing with the noise of running machinery, accompanied by the ordinary amount of smoke and dirt.

The merits of batteries have been recognised by several of our London central lighting stations—viz., Metropolitan at

Whitehall, Chelsea Company, the Kensington and Knightsbridge Company, the Cadogan Company, the Westminster Company, and will be installed in the new central station now being erected by the St. Pancras Vestry.

INSTITUTION OF ELECTRICAL ENGINEERS.

DISCUSSION ON "SOME POINTS CONNECTED WITH MAINS FOR ELECTRIC LIGHTING," BY W. H. PREECE, F.R.S., AND ON "THE MOST ECONOMICAL METHOD OF FEEDING A LOW-PRESSURE NETWORK," BY R. E. CROMPTON. (*Authorised Abstract.*)

Mr. Swinburne remarked that in 1889 he had discussed the subject of disturbance in telephones, with reference to concentric cables earthed at one end. Many persons thought no trouble would arise from such a course. This, he believed, was a mistake, for the outside conductor, being near earth, had a considerable capacity relative thereto. If a large current, say of 250 amperes, was passing, the pressure between the two ends of the outer conductor would be about 210 volts, and this would cause a considerable earth current to surge backward and forward between London and Deptford. The effect of these currents had, he believed, not yet been observed, but it would become noticeable when the load got heavy. Mr. Preece, he said, thought earthing the secondary of a transformer tended to lead the current into temptation, but, as a matter of fact, the temptation was diminished by earthing the middle of the secondary. If this be done, neither secondary main could differ by more than 50 volts from the earth potential; whereas, if one end be earthed or neither, the risk and danger were considerably increased.

Mr. Addenbrooke said that the object of Mr. Preece's paper was to point out the economy of the high-pressure principle, whilst that of Mr. Crompton's was to impugn that principle. On examining the question as to the cost of high-pressure mains, he found that to give a 10 per cent. loss in 2,400 yards of feeder supplying 100 kilowatts at 2,000 volts, would require a $^7/_{14}$ cable, and this of best Silvertown make would cost about £165 per mile. This would give the cost of cable about £400, instead of £1,300, as stated in Table I. The cost of the culvert or pipe was taken the same for both the high and low pressure feeder. This, he thought, was unfair to the high-pressure system, and the cost of the transformers and apparatus was also too high. Altogether, the cost of the high-pressure feeder ought to be put at about half that of the low-pressure one, under the conditions there stated. These conditions were, however, not practical ones, for no A.T. engineer would allow a drop of 10 per cent. in so short a feeder; 2½ per cent. would be much more reasonable. Taking this drop, the cost of the cables would come to about £1,300, but the 7½ per cent. saving would mean an increased revenue of about £160 per annum.

Mr. Jackson described the method of laying underground concentric mains as carried out by the Newcastle-upon-Tyne Electric Supply Company, and exhibited samples of the work. The system, he said, was a draw in and draw out one, using cast-iron pipes, and concentric cables for 2,000 volts pressure. The joints were made, in junction-boxes by bolting copper rings cast to thimbles, in which the ends of the cables were sweated to the tops of porcelain insulators. The same points served also as connections for service lines. The advantages claimed were simplicity and small cost, a six-mile circuit to feed 12,000 lamps, with a variation of pressure never exceeding 6 per cent., having been laid at about £1,100 per mile. At the suggestion of the President, Mr. Jackson promised to communicate further details in writing for publication in the *Journal*.

Mr. Kapp said the case which Mr. Addenbrooke had made out for the A.T. system was not strong enough, for Mr. Crompton's calculations were vitiated by not taking the extra cost of plant into account. With a low-pressure feeder of 90 per cent. average efficiency, about 30 per cent. more boiler, engine, and dynamo power would be required, as well as 30 per cent. more wages, etc., than for a high-pressure system. Mr. Crompton would thus have to lay down 30 per cent. more plant and pay 30 per cent. more wages and interest for the privilege of using a low-pressure feeder.

Major-General Webber said Mr. Crompton wished them to believe that the A.T. people had now found that it would be necessary to use a low-pressure network, such as used in direct-current distribution. This, he said, was by no means new, for Mr. Ferranti, as long ago as 1885, described a system like the one now mentioned by Mr. Crompton. Referring to Table II., he noticed that its author there admitted that 25 per cent. of the 2,400 yards of feeder would have to be laid in tubes. In practice, however, it was found that culverts could only be used for about one quarter of the total distance, and making this change would increase the cost of the low-pressure feeder by about £2,000; the interest would also be considerably augmented. Speaking of the 1 per cent. depreciation allowed on culverts and copper, as against 8 per cent. on cables, he said there was no admitted proof that the upkeep of one would be only one-eighth of the other. This point he (Major-General Webber) had referred to in his paper read last winter, but he was now sure that the figures 1 per cent. and 8 per cent. could not be admitted.

Sir W. Thomson enquired what ratio the energy sold had to that generated in the various systems of distribution. In his opinion the comparison would be favourable to the low-pressure system whenever it was practicable. In dealing with large conductors, both Mr. Preece and Mr. Crompton seemed to have ignored the fact that the conductivity was less for alternating currents than for direct ones. Conductors of two centimetres diameter offered 8 per cent. more resistance when the frequency was 80, whilst for three centimetres diameter the increase was 31 per cent. Mr. Preece's square inch section conductor would offer 25 per cent. more resistance to an alternating current of 80 periods per second, and at 100 periods the increase would be 30 per cent. As this was a matter of considerable importance in low-pressure networks, he would suggest that all cables for currents greater than 200 amperes be made with jute, instead of copper, in the centre. On the whole he thought it injudicious to rush to alternate currents for distribution purposes, and he himself rather inclined to continuous-current distribution by feeders as described by Edison. He was quite aware of the processes which had led to the A.T. system being usually preferred, and of the great advantages which in some cases could be realised by its use, but he believed that in future the direct system would predominate. The general idea in putting the generating station at a distance was to obtain cheaper coal, but he doubted whether more than 6d. per ton could be saved in this way. The possible use of condensation was another item, but so far as he was aware triple-expansion condensing engines had not come into use for lighting purposes. Rent of land was, however, an important consideration, as well as the necessity of diminishing vibration. Both these told in favour of the distant station, and in his opinion no other consideration ought to prevent engineers from putting their stations as near as possible to the consumers.

Mr. A. Siemens thought the principal object to be aimed at in designing stations was simplicity, and the designs for a particular district must be guided largely by local circumstances. In his opinion the discussions on both Mr. Crompton's papers had converged too much on high and low pressure. Speaking of cables, he said that, in addition to the theoretical conditions referred to by Sir W. Thomson, practical and financial points had also to be kept in view. In making concentric cables for the London Electric Supply Corporation they had found that putting in a jute core increased the diameter of the cable, and added considerably to the cost. It was cheaper for them to put in extra copper to make up the conductivity. Referring to Mr. Crompton's estimate for the upkeep of mains, he concurred in Major-General Webber's protest against the 8 per cent. for insulated cables. As a matter of fact, neither the cables put down in Berlin in 1881, or those in use at Bradford, had cost a farthing for upkeep since they were laid. In his opinion the upkeep of cables ought not to be put at a higher figure than that allowed for culverts.

Mr. Swinburne said the "skin effect" could be minimised even in large conductors, by making them, say, in six smaller cables stranded round an inactive centre.

Sir W. Thomson pointed out that if each wire of such a cable was as much outside as any other wire, the full conductance would be obtained, but this condition was not fulfilled in cables as ordinarily constructed; and in conductors two or three centimetres in diameter, the conductivity for alternating currents is seriously diminished. With reference to the upkeep of cables, he thought that if properly constructed and laid the upkeep should be practically *nil*.

Mr. A. E. Mavor said that by soaking the separate wires in an insulating medium before stranding, considerable resistance could be got between the strands; a light serving of cotton did not seriously increase the diameter of the cable. In this way he thought Mr. Preece's square inch section could be obtained without much diminution in conductivity for alternating currents. He characterised Mr. Crompton's estimate of £1,300 for 2,400 yards of concentric cable as absurd, and he assured Mr. Preece that great attention was being given to the construction of mains. He was also of opinion that rubber would be superseded by cheaper dielectrics. On the subject of feeding a network he had no doubt but that high-pressure cables would be much cheaper than low-pressure ones.

Mr. Preece, in reply to Sir W. Thomson, said that in one alternate-current system with which he was acquainted the coal burnt per unit sold was 17lb., whilst per unit generated it was 8lb. In Rome, however, these numbers were 10lb. and 8½lb. respectively. This satisfactory result he attributed to the system of "banking" the transformers. Of direct-current systems, he said that Mr. Crompton's statements were not corroborated by the company's return, for whilst he (Mr. Crompton) gave 7lb. to 8lb. as the consumption per unit generated, and 8lb. to 9lb. per unit sold, a director informed him (Mr. Preece) that they did not get paid for two-thirds of what they generated. He hoped that before long it would be usual to get an indicated horse-power hour for 2lb. to 2½lb. of coal, and that 6lb. or 7lb. per unit sold would suffice. Referring to the one square inch section of copper mentioned in his paper, he said this was taken merely as an illustration. In practice, none of the mains need ever exceed a quarter of a square inch in area, and, as shown in his paper before the British Association, the reduced conductance of such sizes for ordinary frequencies was not important. Sir W. Thomson, he remarked, had said a great deal in favour of low-pressure systems with numerous stations; but in so doing he had apparently overlooked the fact that working expenses were greatly increased by this duplication of stations. In designing the Bristol scheme two stations were found to be much more expensive than one, and it was for this reason, and on account of its greater "simplicity," that the alternate-current system with one station had been chosen. The three-wire system, he said, was not financially possible at distances greater than half a mile, whilst for five wires the limiting distance was about a mile.

Mr. Crompton, not being present, did not reply.

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AMERICAN STATISTICS.

Figures are proverbially misleading, and the figures connected with electrical progress in America more so than usual, unless the reader keeps well in mind the different conditions existing there. It is, however, well to occasionally consider the progress in America as compared with England, always, as we say, recollecting the differing conditions. Briefly, the position in America is that the first commercially successful electric street railway was built in 1886, or five years ago, and now America has 2,931 miles of such railway. This gives an average construction of mileage per year of nearly 600 miles. When electric traction is compared with other modes of street traction in vogue in America, we find 554 miles operated by steam motors, 527 miles worked by cable, and 5,713 miles actuated by animal power. The rapid progress of electric traction shows conclusively that in places where "vested interests" are not, electricity has the preference. By vested interests being absent, we mean that horse-worked tramways do not exist, but that most of the electrically-worked lines are laid in virgin fields. Again, American citizens are not in most cases living in overcrowded cities, their æsthetic tastes are not allowed to stand in the way of business requirements, hence overhead wires are permitted to a greater extent than in England. In our highly-civilised land overhead wires are not allowed promiscuously to those whose "cause is just," but only to those who have been able to get their "blow in first." Thus, in America, the 2,931 miles are mostly operated by the overhead trolley system. The rolling-stock consists of 4,407 motor cars, and 6,000 ordinary passenger cars. The speed averages seven to 10 miles an hour, with a maximum of 20 miles, and the maximum horse-power generated by a single electric car is 75 h.p. Of storage cars, the most successful seems to be the Waddell-Entz car at Philadelphia. Turning from America to England, what has been the progress here? Certainly not at the rate of 600 miles a year, nor even at the rate of 60 miles. In fact, we have not 60 miles of electric tramways all told, and the difficulties those who attempt to exploit such work have to encounter are greater than those entailed by the mythical labours of Hercules. Coming to electric lighting figures, the comparison is not so greatly in favour of America, still remembering that gas is to be found in almost every town and in many villages in this country, where electricity has to compete with a real "vested interest." In America, on the contrary, electricity has in many places been the first artificial illuminant in the field. It is not surprising, then, to find the Americans operating from central stations no less than 1,740,000 incandescent and 154,000 arc lights, while it is estimated that 900,000 incandescent and 25,500 arc lights are operated from isolated plants. These figures will at any rate show what a vast electrical engineering industry has been created during the past 10 or 12 years. Those who have any doubts as to the future of the industry in this country need only look to the action of some of our largest towns in this matter. After patiently waiting—waiting longer than many of us thought wise—great activity is now being shown, and in the course of next year some of the finest central stations that can be designed will no doubt be in full operation.

ENLIGHTENING THE ORIENTAL.

John Chinaman will have nothing to do with the telephone because he cannot understand it—this is to all intents and purposes the result found by Englishmen who have tried, in the shape of the China and Japan Telephone Company, to introduce this convenience into China. The company has a capital of £20,000, of which some £19,000 (most, it is true, taken in shares) have long since gone to original and sanguine promoters, and have to show for it some two or three hundred subscribers in Shanghai and Hong Kong. The numbers, we believe, are 180 or so in Shanghai and 80 in Hong Kong. This can hardly be as satisfactory a result as was once anticipated; and the result is attributed to the old difficulty of inducing China to throw itself open to Western civilisation. The same trouble is found with all three of our great instruments of civilisation—railways, telegraphs, and telephones. But if the companies working these inventions do nothing but wait for the country to be opened they will wait for aye, and it could hardly be thought that £20,000 capital is needed to put telephones in Shanghai and Hong Kong alone. It is exactly these agencies that have the chance—nay, the only chance—of bringing in the Western civilisation. It lays with them, if with anybody, to bring about this great desideratum to the world, and shew, in one way or another, worth for their capital.

The nature of John Chinaman is "childlike and bland," we are often told—childlike he certainly is in many directions, from the limited or one-sided range of his education. Methods found to succeed with men have failed with children, and it is probably so with ignorant adults. The young and inexperienced mind is often frightened—at sweeps, at bogeys, at mere darkness. They are occasionally so with locomotives also, until the thing is properly explained. Perhaps it is from the want of sufficient recognition of this same sort of childish terror and superstitious feeling that the locomotive and the telegraph have been so often tabooed. There has been hitherto no point of contact by which the Chinese mind can realise the awful possibilities that lie hid behind the Englishman's creations. Explained, properly shown the gradual development, given some plausible *rationale* of the process or machine wished to be introduced, and perhaps he will take more kindly to it. Anyhow, the fact stands before us that it will be when the telegraph, telephone, and railway are introduced, and not till then, that Western civilisation will penetrate the Celestial Empire. It lays, therefore, with the managers of these enterprises in the Far East to carry out the crusade of conversion. Exhibition of their wonders and the usefulness of them is not enough: they must have in their hands the weapon of simple and satisfactory explanation. A sample method of inducting the Eastern intelligence to the wonders of the telephone is suggested in another column—we can leave it to the managers of telephone companies to get it translated into Chinese and circulated among the authorities and the common folk. Until every inhabitant can understand and appreciate, at least approximately, the various operations or natural actions that occur in seeming wonders, the railway engine will still seem a huge, destructive, fearsome, demon-like being, to be overthrown and killed if possible; the operations of the telegraph and the telephone will be thought a species of miraculous, awesome, fever-spreading, unhallowed incantation—instead of the beneficent instruments of liberty and progress we know them on this hemisphere.

CAMBRIDGE.

Our contemporary the *Electrical Review* seems to have assumed as its *rôle* in life the contradiction of everybody in general and ourselves in particular. It assures its readers that it has information which others cannot possess. Its misfortune is that usually other papers give its exclusive information first, and its office is then to contradict. With regard to Cambridge and Newcastle, we gave the report. Our contemporary did not. The report speaks for itself, so that it passes the understanding of mortals—except those connected with the *Review*—to see where our "statements are quite incorrect." Let us put the *Review's* case another way. The report and our comments appeared on May 22. The latter did not perhaps meet the approval of certain people at Newcastle, and a method was devised to reply to those comments. The article in the *Review* of June 5 then, we take it, is the inspired reply. Good. We are told Crompton's system is a low-tension one, with accumulators, and the cost for coal is therefore less than at Newcastle with a high-tension system. Just so, wise and sapient *Review*, but we happened to show that the continuous saving of coal would permit of a largely increased initial expenditure, and still be a saving. We are told that the Newcastle coal is bad. That is a lame dog to help a blind man over a style, and is always put forward as an excuse. We have not said that Parsons cannot produce a more efficient engine. We said that the Cambridge Committee should not accept "if" and "should" in lieu of actual facts. We know what Parsons's ordinary engine can do, because *we have tested it under stringent conditions*, but we don't pretend to *know* what his improved engine will do; that at present, as the *Review* states, is hearsay evidence. It speaks much for the trustfulness of our contemporary in human nature that it should so often accept interested hearsay evidence, and give it to the public as authentic, without even quoting *cum grano salis*. If our contemporary is unable to put two and two together, and to understand that the cost of extra coal, and the cost of putting that extra coal into the firebox, is more than an equivalent for the cost of maintaining accumulators and depreciation, which he invites us to consider, then we are unable to help him. Clearly it is in the interest of Mr. Parsons, or whoever inspired the *Review*, to do business. We have no objection to raise against this; but what we do so strongly condemn is the acceptance, as it seems to us, by the committee of promises instead of performances. We have said before, and we repeat it, that very often an initial expense of extra thousands is warranted, and is a saving when the cost of maintenance is duly considered. Perhaps when our contemporary has paid the same attention to "engines" as it has to "Elmore Companies," we may look upon its statements with some degree of interest.

ELECTRICAL SUBWAYS.

The difficulties of establishing electric light distribution in large towns do not arise so much from the actual manufacture of the plant as from two other little matters—one the finance, the other the subways. In the case of the City of London, the first difficulty was boldly taken by the horns, by the formation of a separate company to attend to the finance. It would seem as if it were not impracticable to follow this idea in the case of the other great difficulty—the subways. At any rate, we notice that in Cincinnati this course has been adopted, and an electrical subway company has been organised, of which Mr. Chas. Fleischman is president, and Mr. Nelson Perry electrician and engineer. The object of this company is solely to build subways throughout the city, and to lease them for the electrical conductors of various kinds—telegraph, telephone, light and power. The company has been chartered by the State, and expects its franchise from the city authorities to follow. If in the City of London we could have a system of spacious subways, such as indicated, to be ready, by means of proper manholes, to take the place of the 3,613 little nibblings of breaking up and putting down, a very good and useful work would have been done once and for ever. We believe that the question is even now under the consideration of the City authorities, and among men so keen and businesslike in company matters as can be found amongst them, the hint we have thrown might possibly be found worthy and capable of adoption.

LONDON WITHOUT OMNIBUSES.

The streets of London have worn an unwonted appearance all this week. The omnibus men have struck and few buses are running. And, strange to say, no one seems very much put out about it—except, of course, the companies and their shareholders—and the streets have taken on a quietness, airiness, picturesqueness that is ordinarily quite wanting to the London thoroughfares. Inconvenience there must have been, but it is not noticeable. Cabs and trams and railways have benefited, and so have the dwellers in town, by reason of the freedom of the streets; and the walkers, by reason of added exercise. It is impossible to avoid drawing the conclusion that London would be a far more pleasant place if there were few or no omnibuses. The air is void of hoarse and reiterated cries; the crossings, for once, are safe; the dust of trampling feet is less penetrating; the streets are quite evidently not torn and worn by wheels and hoofs of those who pay little for the renewal. Were some additional means of rapid transport provided cool and cleanly underground, in the shape of the tubular electric railways, running east and west and north and south along the great lines of transit, we could well afford to see the omnibuses almost improved off the face of the metropolis. The object lesson we have had this week will be all the more noticeable when the buses commence running again, and will remain a useful and just argument for the extension of electric railway enterprise.

ARMATURE REACTION IN CONSTANT-CURRENT DYNAMOS.*

BY PROF. H. S. CARHART.

The experimental work of a laboratory of electrical engineering convinces the observant investigator that the literature of dynamo-electric machinery is not only deficient in matters pertaining to constant-current machines, but contains reiterated statements that are wide of the facts.

Thus, we are told that regulation by means of the movement of the brushes round the commutator cylinder is impracticable because of the destructive sparking that ensues, while the fact is that with machines having a closed coil armature, and particularly those of the Gramme ring type, the current may be kept constant from full load to no load by rocking the brushes forward without any appreciable sparking. The explanation of this remarkable method of regulation is the enormous influence of the armature on the magnetic circuit of the machine. At the same time, it must be confessed that uniformity of field contributes to the result, but great uniformity is not essential.

My remarks will be directed, not so much to the explanation of the sparkless commutator of a machine which regulates by rocking the brushes round the commutator cylinder, as to the part played by the magnetism of the armature of a constant-current dynamo.

In the ideal simple dynamo the lines of force are supposed to traverse the interspace lying in their path between the polar faces and the armature core with almost perfect uniformity in every part. But it is well known that this is only approximately true even when the field magnet is independently excited and the armature is at rest with no currents flowing through it. A deformation and redistribution of the lines of force begin as soon as the armature is set in rotation, unless the lamination is carried to an extreme, and the brushes are not down so as to short-circuit sections of the coil as they pass under them.

With the machine self-excited, and the external circuit closed, so that a current circulates round the armature, then the "battle of the giants" begins. For the armature core is magnetised both by the induction from the field and the current circulating through its own coils. In other words, the flux of magnetic force through the armature is the result of two magneto-motive forces. The relative influence of the one generated in the armature itself will depend upon the design and construction of the machine in a manner which I shall now proceed to explain.

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* Paper read before the Chicago Electric Club, May 25.

Constant-potential dynamos and constant-current dynamos possess diametrically opposite properties in those particulars which affect armature reaction.

It is essential in the first place that the armature resistance of the former should be reduced to the lowest limit of making a very intense field, and by reducing the convolutions of wire to as small a number as possible; hence the magnetic effect of the armature is reduced to small limits for this reason.

Again, every builder of dynamos knows that the field cores and pole-pieces of constant-potential machines should be heavy in comparison with those of constant-current machines. The iron in such machines must be kept below the so-called saturation point, even at full load, so that the field will respond by the series winding to the increasing load with additional lines of force, and thus make up for the increased loss of potential in the armature. Whenever, therefore, the current increases in such a machine, the field-magnet responds to the increase to an extent fully equal to that of the armature. The relative influence or reaction of the armature is thus kept within narrow limits.

The well-designed constant-current machine is very different from all this. Fig. I is a "characteristic curve" made from a 25-light machine with a Gramme ring. It is simply a curve drawn with the currents and the volts at the terminals as co-ordinates. This curve exhibits both the saturation of the field magnet cores and the reaction of the armature. It will be observed that at 10 amperes the curve is well over its maximum and the reactionary droop has set in. Such a curve, when corrected for internal loss of E.M.F., represents approximately the curve of magnetism of the field.

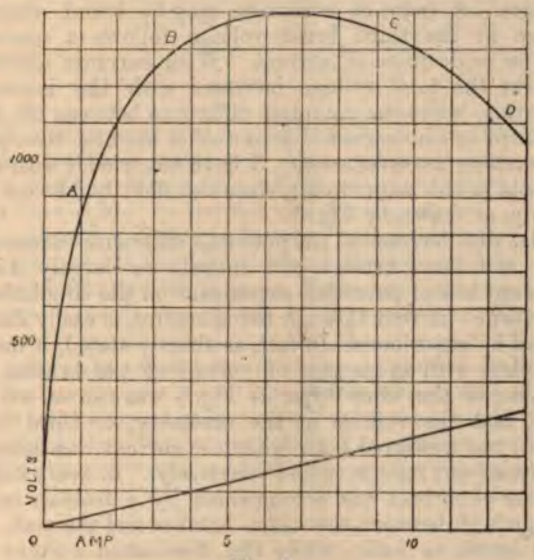

FIG. 1.

Now, a constant-potential machine works on the rising part of the curve, as from A to B, so that the field magnet may respond promptly to the rising current. The magnetism is just at that exquisitely sensitive stage when it feels every change in the current, and when the permeability has a nearly constant value. The constant-current machine, on the other hand, works preferably to the drooping part of the curve between C and D. It thus becomes in a measure inherently self-regulating or automatic; for any increase in the current actually diminishes the E.M.F., thus checking the rise of current, while a decrease of current causes the point traversing the characteristic to move backward along the curve and thus upward. The consequent rise of voltage tends to sustain the current at its normal value. This feature of a constant-current machine permits of larger armature reactions, and, moreover, gives to the machine that stability so essential to prevent surging when the machine is run on arc lights. If the machine were working on the outer side of the bend or crown of the curve, any sudden increase in lamp resistance at the carbons, such as often occurs, reduces the current and so reduces the ampere-turns round the field magnet, thus causing the point denoting voltage to run rapidly down the curve on the left. The trouble is thus cumulative, and the machine drops its load by losing its excitation, to recover it again only after the carbons have dropped together. The drooping characteristic gives to a series arc machine a stability and self-control which enables it to check small irregularities of circuit resistance. The field magnets of such a machine are not greatly sensitive to moderate changes in the current. It possesses that self-corrective property so essential to steady working on good arc lamps.

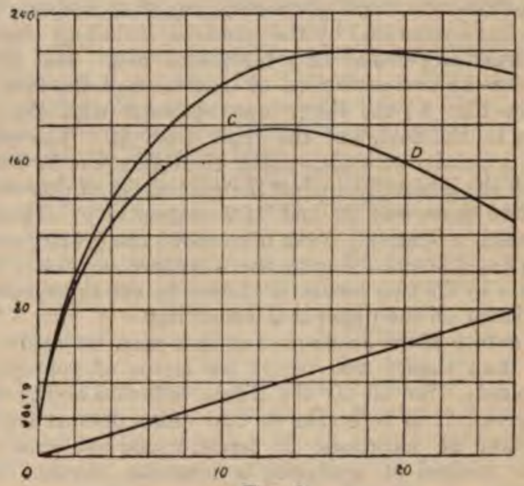

FIG. 2.

The characteristic of Fig. 2 illustrates a different design and a different state of facts. It was taken from a machine with a Gramme ring, built in Ann Arbor in the early spring of 1877, after designs of Prof. J. W. Langley. It has a capacity of fully 5,000 watts at a speed of 1,400 revolutions. So far as I have knowledge, this was the largest dynamo machine built in this country at that date. Viewed from the standpoint of present knowledge and experience, it is faulty in design and of inferior workmanship; but when built it embodied the latest facts known to the art.

It will be observed that at 10 amperes the field is not up to the saturation point, and the curve has not begun to bend over. Hence this machine serves to illustrate the quality of instability when run on 10-ampere arc lamps. The current runs with remarkable periodicity up to a maximum of about 12 amperes depending upon the position of the brushes, and then down to zero, when the carbons all drop together and the field again builds up. It would run low-tension lamps successfully without doubt, though I have not had the opportunity of trying it. At 18 amperes the working part of the characteristic would lie well over the crown where the field possesses greater stability. The lower curve is the external characteristic, and the upper one that of potential differences at the brushes. The core of the armature of this machine consists of iron wire; the field magnet cores are composed of six flat plates of wrought iron, while the yoke and pole-pieces are cast iron. The commutator has only 26 segments, but the sparking is slight.

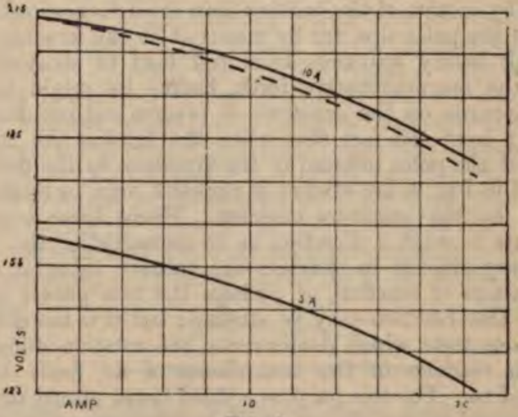

FIG. 3.

To test the effect of the armature currents on the voltage, the field was excited by a separate machine, first with five amperes and subsequently with 10. With a fixed position of the brushes the external resistance would gradually diminish, while the current taken from the armature increased. Now, if there were no reactionary influence of the armature, the curve connecting together amperes and total voltage generated by the machine, including the loss in the armature, should be a horizontal line. The actual curves for the two conditions of excitation of the field are given in Fig. 3; the lower was obtained with the five amperes in the field, and the upper with 10. The actual drop in potential with the smaller excitation was 37·6 volts and with the largest 33·4; but the percentage of depression in the two cases was 23 and 15·7 respectively. Thus, as anticipated, a relatively weak field shows the greater modification and distortion due to the armature currents. The difference in the two curves is shown by the superposition of the lower on the upper as a dotted line.

The nature of the armature reaction may be made out partly from theory and partly by means of appropriate experiments. So far as the direct influence on the field is concerned, it is referable to two quite distinct factors, which may be expressed in terms conformable to the modern method of analysing a magnetic circuit. This consists in expressing the magnetic flux as the quotient of the magneto-motive (M.M.F.) force and the magnetic resistance. The currents circulating round the armature reduce the magnetic flux both by increasing the magnetic resistance or equivalent length of the magnetic surface and by generating a counter magneto-motive force. The former is affected in just that portion of the circuit where the resulting change is the greatest—that is, in the air interspace adjacent to the polar faces. The lengthening of the magnetic circuit in the vicinity of the polar margins, C C, (Fig. 4) was well illustrated and suitably enforced by Mr. Dow in his paper before this club on April 6. The other factor appears to play a much more important part in regulation by motion of the brushes than the deformation of the field at the polar tips, for by means of it the brushes may be kept nearly sparkless from full load to short-circuit. That the magneto-motive force, having its origin in the ampere-turns on the armature is inverse and not direct is evident from the fact that when the brushes are rocked forward the poles induced in the armature by the field, as at BB¹ in Fig. 4, are always of opposite sign to those produced by the armature currents. Hence these currents circulate in such a direction as to demagnetise the field. It is very difficult to estimate the relative value of those two factors of reaction, or perhaps the two phases under which this reaction may be studied; but it is not difficult to devise tests which demonstrate the relative difference of this reaction in the two classes of 24 fields before referred to. For this purpose a third brush placed slightly in advance of one of the main brushes serves a useful purpose.

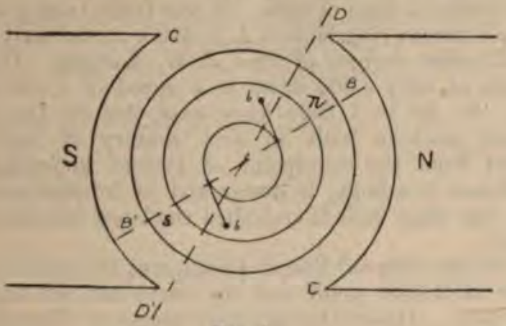

FIG. 4.

Imagine the brushes placed on the line, B B¹, in the figure, and the external resistance such that the normal current is flowing through the circuit; and let the voltmeter be connected with one main brush and the third brush, which makes contact with the commutator cylinder one or two sections in advance. If the current is increased by cutting off part of the load, what may be expected to occur in the voltage of this supplementary circuit? Will it increase or decrease? That depends entirely upon the condition of the field as to separation. If the total E.M.F. of the generator remain constant, then, as with a battery, the increased current means increased loss of potential in the armature, and, therefore, a smaller difference of potential at the brushes, and if smaller at the main brushes it will be smaller between the point of derivation of the supplementary circuit. If the field is magnetised to that extent that it is only slightly sensitive to changes in the current, then an increased current will cut down the potential difference between the brushes for the additional reason that while the influence of the field is not increased that of the armature is. With the field less highly excited, so that the permeability of the iron is not much reduced below its maximum, the dynamo responds to an increase of current with a denser field of force, and a higher E.M.F. The growing current may then produce a greater effect in the field magnet than in the armature. In that case the potential difference both between the main brushes and in the third brush circuit will rise with the current.

Both these conclusions are verified by experiments of the machines whose characteristics are given in Figs. 1 and 2. In the old Gramme ring machines, with currents under 10 amperes and with the third brush two sections in advance of the main brush, an increase of current is accompanied by an increase in the voltage both between the two main brushes and in the third brush circuit as well. But with larger currents, approaching 20 amperes, cutting out resistance and increasing the current decreases both voltages. A point of excitation may be found where no change in the third brush voltage follows a moderate increase or decrease of current. With currents above 10 amperes the total voltage increases with the increasing excitation, while the potential difference between the main and third brush decreases. In the other machine the change is invariably an inverse one. I have not tried it with small currents in the main circuit, since the field builds up very rapidly, as shown by Fig. 1.

That this decrease in the potential difference between the main and third brush is not entirely or largely due to increased loss of potential, consequent on the circulation of an enlarged current through the armature, is easily demonstrated by experiment. In fact, as already stated, it may be coincident with an increase of voltage at the brushes. A machine of the same type as Fig. 1 was run at varying loads, and the voltage in the accessory, or third brush circuit, was measured both when the current was increased by cutting out resistance and conversely. In every case an increase of current was accompanied by a decrease in the voltage both between the main brushes and the main and third brush as well; while the diminished current was responded to by an increase in voltage in both places. Moreover, both the increase and decrease were too large to be accounted for by loss due to resistance in the armature. I will select only two fair average examples out of many observations. Thus: current 10 amperes, total voltage 240·1, third brush 15, current increased to 11·41 amperes, total voltage 211, third brush 12. Now the resistance of the armature from brush to brush was 4·6 ohms hot, and the third brush was two segments in advance of the main brush. Total number of commutator bars 72. Hence the resistance of the two sections of the armature to half the total current was 0·52 of an ohm. The loss of potential due to an increase of current from 10 to 11·41 amperes or from 5 to 5·7 through either half of the ring was 0·37 of a volt. But the total drop was three volts, or 20 per cent. Again, with a current falling from 10 to 8·3, the voltage rose from 242·8 to 271·8, and the third brush voltage from 14 to 18. In this case the half current decreased 0·85 of an ampere. The gain in voltage in the third brush circuit alone should have been only 0·44 of a volt if this were the only reason for it. It was actually four volts. The imperfect contact of the third brush rendered exact readings difficult, but the variations were always much in excess of those calculated as above.

With this third brush set very close to the main one, so as to get a difference of about four or five volts between them on a 20-light machine, I have observed that the cutting out of a single lamp, whatever the total load might be, produced a reversal of the third brush current when this circuit contains relatively high resistance, and if the brushes are automatically moved by a regulator which produces a gentle vibratory motion of the brush system back and forth, the third brush current will reverse with every backward oscillation of the brushes. The only interpretation of these facts which seemed to me at the time plausible was that the armature reaction was sufficient to cause the neutral line or neutral part of the field to follow the brushes quite closely in their motion about the commutator to maintain a normal current; and this explanation I gave to my class on dynamo machinery and maintained in a semi-public way. But further experiments, directed to the exploring of the commutator for the purpose of ascertaining the relative potentials of the various parts, have convinced me that this explanation is not the correct one.

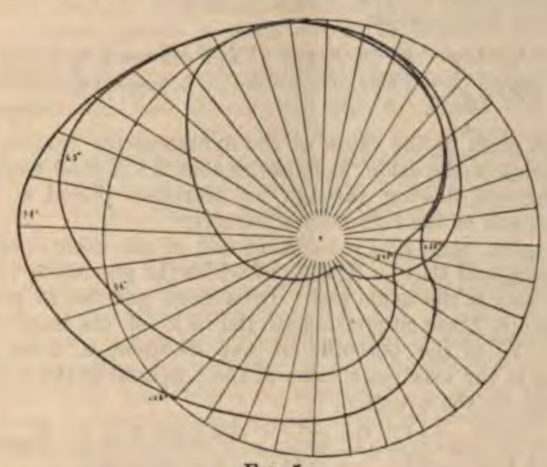

Fig. 5.

The method consisted in attaching to the brushholders a circular frame of insulating fibre, with slots cut every 10deg. in its periphery by a milling machine, and employing these slots to hold in succession a third brush.

The potential difference between one of the main brushes and this movable third brush was measured entirely round the commutator with different loads, and always with 10 amperes through the circuit of the machine. The first position of the brush was such that the potential difference was zero. The several values with no external load, with a resistance equivalent to three lamps, and finally equivalent to nine lamps, I have platted round the circle in Fig. 5. The position of the brushes 0deg. and 180deg., with the machine nearly short-circuited, and with the brushes rocked forward fully 65deg. × 70deg. beyond their positions for maximum load, you will see that the potential ran up to a maximum positive at nearly 80deg. from the positive brush, and then ran down, so as to be identical with that of the same brush at about 128deg. So also a negative maximum was attained at 260deg. The difference of potential between these two positive and negative maxima was 644 volts. The same distance was found when two extra brushes were placed at these two highest points. The line joining these points, usually called the theoretical neutral line, lies forward of the medial line between the magnet poles and is distant about 20deg. from the leading pole tip. All the E.M.F. generated in the coils from 0deg. to nearly 80deg. is therefore counter E.M.F. The same is true of the opposite side of the armature. The points A A in Fig. 6 correspond to the two maxima described. At these points the E.M.F. generated changes sign, and they must therefore be on the neutral line. B B is the line of the brushes.

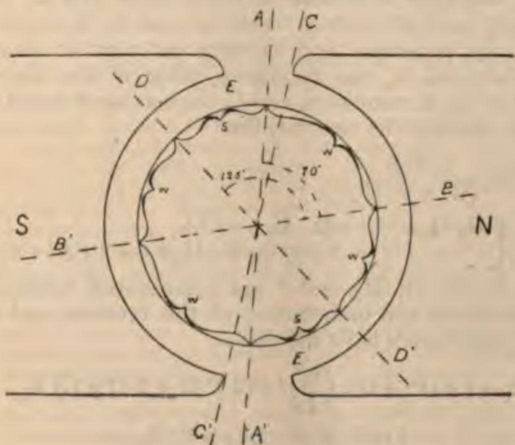

Fig. 6.

With three lamps in circuit, or their equivalent in iron wire resistance, the brushes were rotated backward 15deg. and the points of the highest and lowest potential, as compared with the main brush, were 65deg. and 245deg., being respectively about 168 and 456 volts. With the highest load carried, the brushes were rocked back 50deg. further, and the two main brushes were then very nearly at the maximum and minimum points.

If now we study Fig. 5 we shall find that the region of the commutator on either side of a brush, or the armature coils in these positions, is a relatively weak field, the angular distance through which the potential rises to a maximum being nearly double that required to bring it down again to the level of the main brush. Thus, in the outer curve the maximum is at about 78deg., and it crosses the circle again at 128deg. So the next one attains its highest positive value in the vicinity of 65deg., and crosses the zero level again at 95deg. Similar differences are exhibited on the opposite side of the circle of reference. In Fig. 6 the regions marked W are relatively weak, as compared with those marked S. The places of maximum activity are near the polar boundaries at E. If the several maxima be laid off from the position of the brushes as zero, it will be found that they all fall, as nearly as can be determined, at the same place. This fact is brought out more clearly by plotting the potential differences as ordinates from a straight line as in Fig. 7. From these curves, it is evident that the maximum positive and negative ordinates of the first curve, taken with no load, fall at about 78deg. and 260deg. respectively, corresponding in position, as nearly as can be determined, at the same parts of the field as those of the other curves. I find no evidence in these curves that the rocking forward of the brushes to control the current, with diminishing external resistance, causes the theoretical neutral line to move to any considerable extent.

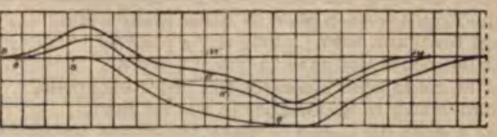

Fig. 7.

I do find, however, that the poles of the armature, which are always at the brushes, exercise a marked influence on the field, wherever they are. It is easy to see that the curves are all flattened out in the vicinity of the brushes, as at B^1 B^1 B^1. This flattened region extends a good deal beyond the limits of the contact of the brushes with the commutator cylinder, though the lapping over of the brushes doubtless contributes to this result. If we imagine a bar magnet placed in a powerful and approximately uniform field of force, or stream of lines of magnetic force, with its own field opposing that of the field in which it is placed, it is easy to foresee the effect it will have in reflecting and scattering the lines of the main field, so long as its own magnetism is not reversed—so long as it retains its own autonomy or system of governing forces within another system.

(To be concluded.)

HOW TELLEE CHINEE FAR SPEAKEE.

It has been complained that the Chinese will not use the products of Western ingenuity—the railway, telegraph, and telephone—for one great reason from a kind of fright, because they do not and cannot understand them. It may be that attempts to explain have hitherto not been such as would be adapted to the childlike wonder of the Chinese when brought into contact with agencies, such as steam and electricity, of which they know nothing. Explained simply and rationally, they might take more kindly to these inventions. The following is, therefore, suggested for translating in Chinese.

How the Englishman Speaks Afar.

When any man speaks, and air comes out of his mouth,
A sound is made and the air trembles around :
The trembling spreads around the air and strikes against the ear of his friend,
And the friend hears what he wishes to say,
And understands his words, and we call it speech.
Everyone knows this.
Everyone knows that a man can speak from room to room, from roadside to roadside, through the air ;
Can shout across the fields,
Or even up the mountain side.
But soon his voice is lost, it fades away,
And one can hear no more,
Though still we may see him waving his hand in the distance.
When a man goes far away from his town
He cannot speak to those at home ;
He must wait and wait till he returns ;
Or, till his words are written on paper
And the postman rides and rides day and night
And brings the letter from far away home.
But the Englishman found a way to speak afar.
First he wished to speak from house to house
He took a little tin box
He tied a string to the bottom
He stretched the string across to the other house,
There, he tied the string to another little tin box
And then he pulled the string quite tight ;
He gave it to his friend to place to his ear
And went back to his own house.
Then, when he spake into the little box
The sound of his voice made the tin box tremble
It shook the string and the waves ran along the string
Ran into the other box and made it, too, tremble to the sound of his voice;
And the sound of the voice came along the string
And his friend heard all that he said.
And this everyone can try for himself in the same way.
So now they could speak and understand between house and house.
And soon they tried from village to village
But when very far, the sound died away
The wave would not travel along the string,
And when far away the man could not hear his friend any more.
Now the Englishman wished to speak many miles,
Between town and town, a long day's journey
So that he should not have to travel to speak,
So that he could send messages and order his goods,
And could speak to his brother in the far town.
Long he sought for means to make the waves travel long, long distances
And after many years he found this :
One day he took a piece of copper wire
And he tried to send the waves of the voice along it.
He took a piece of white metal, of zinc—
And he dipped it into acid ; and the acid eat the zinc ;
Then he touched the copper wire with the zinc
And he found that he could make waves go along the wire,
Waves that would travel far faster than the voice can go,
Waves that would go as quickly as the
Flash of the sun from a mirror—
And he knew, at last, he had found his desire.
Then he took again his little tin box
And he fastened the copper wire to this ;
He strung the copper wire along the roads from post to post,
He took it over hill and dale
And over streams and through woods ;
He led it from one town to the other,
And there in the other town he fixed his other tin box to the end of the wire.
Then he carefully fixed his zinc and his acid
And he touched it to the copper wire ;
He spake into the tin box
And the tin box trembled as before with the sound of air from his voice,
And the trembling made the waves from the zinc go like a flash along the wire ;
In one moment they thrilled through to the end
And in their turn made the tin box tremble to the sound of the voice ;
And the sound of the voice came as before into the box
And the friend far away could hear his speech.
He could speak his thoughts to his friend
And could ask his friend questions
And the friend could ask answer him—
So quickly went the trembling waves along the wire
That it was like as man talking to his friend in the next room.
Hundreds and thousands of these little boxes
Are used in the Englishman's land ;
Every day men speak with them to their friends far away.
And men call them the "Far-Speaker," or

THE TELEPHONE.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING, MEMBER.

(Concluded from page 560.)

The equation (36) enables the pressure at any point in the cable, as given by a voltmeter, to be predetermined from the pressure at the origin. The current flowing through a low-resistance ammeter placed at any point in the cable can also be deduced from the equation (36), and its maximum value, I, is shown by Mr. Heaviside to be given by the equation,

$$\mathrm{I}^2 = \frac{\mathrm{V}_0^2\,\mathrm{C}\,p}{\sqrt{\mathrm{R}^2 + p^2\,l^2}}\;\frac{e^{2\,\mathrm{P}\,(l-x)} + e^{-2\,\mathrm{P}\,(l-x)} + 2\cos 2\,\mathrm{Q}\,(l-x)}{e^{2\,\mathrm{P}\,l} + e^{-2\,\mathrm{P}\,l} - 2\cos 2\,\mathrm{Q}\,l} \qquad (37)$$

This gives us the value of the dynamometer reading at any point in the cable. It shows us that if l is great enough the current flowing through an ammeter placed at the distant end of the cable would be zero.

Suppose, next, that the distant end of the cable is open-circuited, and that an E.M.F., of which the maximum value is V_0, acts at the home end. It is then possible to prove that under these circumstances the ratio of the maximum value, V, of the potential at any distance, x, from the origin, to the maximum value of the potential at the origin, is given by the equation,

$$\left(\frac{\mathrm{V}}{\mathrm{V}_0}\right)^2 = \frac{e^{2\,\mathrm{P}\,(l-x)} + e^{-2\,\mathrm{P}\,(l-x)} + 2\cos 2\,\mathrm{Q}\,(l-x)}{e^{2\,\mathrm{P}\,l} + e^{-2\,\mathrm{P}\,l} + 2\cos 2\,\mathrm{Q}\,l} \qquad (38)$$

If $x = l$—that is, if we consider the potential at the far end, the numerator of the right-hand side becomes equal to 4, and hence, if the denominator is numerically less than 4 for any given cable—it indicates that a progressive rise in pressure along such cable will take place from the machine end to the free or insulated end.

In a very able paper in the *Philosophical Magazine* for January, 1887, p. 21, Mr. Heaviside has attacked the general problem of calculating the current flowing through a transformer at the far end of a concentric cable when an alternator or transformer giving a periodic E.M.F. of maximum V_0 is placed at the other. The paper is not an easy one to read, and was probably still harder to write. Some of the general results are, very briefly, as follows: If L_0 and R_0 are the total inductance and resistance of the transmitter, whether alternator or transformer, and L_1 and R_1 the same quantities for the receiver, and L, R, and C the inductance, resistance, and capacity per unit of length of the cable, and V_0 the maximum value of the impressed E.M.F. at the transmitters, and C_0 the maximum value of the current through the receiver, then

$$\mathrm{C}_0 = 2\,\mathrm{V}_0\,\frac{\mathrm{C}\,p}{(\mathrm{R}^2 + p^2\,\mathrm{L}^2)^{\frac{1}{4}}} \left[\mathrm{G}_1\,\mathrm{G}_0\,e^{2\,\mathrm{P}\,l} + \mathrm{H}_1\,\mathrm{H}_0\,e^{-2\,\mathrm{P}\,l} - 2\,(\mathrm{G}_1\,\mathrm{G}_0\,\mathrm{H}_1\,\mathrm{H}_0)^{\frac{1}{2}}\cos 2\,(\mathrm{Q}\,l + \theta)\right]^{-\frac{1}{2}}$$

where G_1, G_0, H_1, H_0, and θ are complicated functions of the resistances and inductances of the receiver and transmitter, and which have the values,

$$\mathrm{G}_0 = 1 + (\mathrm{P}^2 + \mathrm{Q}^2)\left(\frac{\mathrm{I}_0}{\mathrm{I}}\right)^2 + (2\,\mathrm{P}\,\mathrm{R} + 2\,\mathrm{Q}\,p\,\mathrm{L})\,\mathrm{R}_0 + (2\,\mathrm{P}\,\mathrm{L}\,p^2 - 2\,\mathrm{Q}\,p\,\mathrm{R})\,\mathrm{L}_0\,;$$

$$\mathrm{H}_0 = 1 + (\mathrm{P}^2 + \mathrm{Q}^2)\left(\frac{\mathrm{I}_0}{\mathrm{I}}\right)^2 + (2\,\mathrm{P}\,\mathrm{R} + 2\,\mathrm{Q}\,p\,\mathrm{L})\,\mathrm{R}_0 - (2\,\mathrm{P}\,\mathrm{L}\,p^2 - 2\,\mathrm{Q}\,p\,\mathrm{R})\,\mathrm{L}_0,$$

and similarly for H_1 and G_1.

I_0, I, and I_1 are the impedances of the transmitter, cable, and receiver; and the quantities P and Q have the values given in section 14.

The quantity θ is an angle which is determined from the expression,

$$\tan 2\,\theta = \frac{2\,(\mathrm{A}\,b - a\,\mathrm{B})}{\mathrm{A}^2 + \mathrm{B}^2 - (a^2 - b^2)},$$

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* Paper read before the Institution of Electrical Engineers, May 7, 1891.

where

$$A b - a B = (R_0 + R_1)(R Q - L p P) + (L_0 + L_1) p (R P + L p Q) - (R_0 I_1^2 + R_1 I_0^2) C p P - (L_0 I_1^2 + L_1 I_0^2) p^2 C Q;$$

$$A^2 + B^2 = I^2 + C^2 p^2 I_0^2 I_1^2 + 2 (R_0 R_1 - L_0 L_1 p^2) L C p^2 - 2 (R_1 L_0 + R_0 L_1) p^2 R C;$$

$$a^2 + b^2 = (P^2 + Q^2) [(R_0 + R_1)^2 + p^2 (L_0 + L_1)^2].$$

The question whether the mean pressure at the receiver is greater than the mean pressure at the sending end, or less, will in general depend upon the sign of tan 2θ.

The quantities G_0 and H_0 become equal to unity when the inductance and resistance of the sending instrument are zero or very small.

The practical deduction which may be made from the above investigation is, that when the alternator at the sending end has very small resistance and inductance, the pressure at the receiving end of the cable will be less than the pressure at the transmitting end, for almost any cases which occur in practice; but this is not always the case when the transmitting instrument has a sensible inductance. We may then have conditions under which there is a progressive rise of pressure from the sending to the receiving end.

The time at disposal has not permitted me to do more than sketch out the general results of such investigations as have been made on the propagation of periodic currents through conductors having sensible capacity and inductance. These investigations need to be brought into further comparison with the results of experience, in order that we may see how far they agree with observed facts, and how far they can be trusted as a guide in predicting the results of the application of known E.M.F.'s to conductor systems in which the capacity and inductance can be predetermined.

DISCUSSION.—*Authorised Abstract.*

In opening the discussion **Mr. Swinburne** said he was particularly interested in the subject dealt with in the paper, for he considered it a most important one, and believed he himself was the first to suggest the true explanation of the phenomenon known as the Ferranti effect. When the effect was first observed it was looked upon as peculiar, and various authorities were exercised in finding an explanation. In December last, when he read a paper on alternate-current condensers before the Physical Society, no authoritative statement as to what actually occurred had been published, but he took the conditions and worked backwards to see what the effect ought to be. He then found that putting a condenser on the secondary mains would increase the pressure, and explained the rise by the action of the "leading" condenser current on the magnets of the alternator. Whether the rise might be said to be due to armature reactions or to self-induction was chiefly a question as to what was meant by self-induction. Several persons had attributed the "Ferranti effect" to the transformers, since the rise did not occur when the transformers were not interposed between the alternator and the trunk mains. This difference he showed to be caused by the condenser current in the alternator being four times greater when the transformers were on, and, in addition, the field magnets were only about one-fourth as strong, so that they were more easily influenced by the condenser current. He himself thought any rise due to the transformer would be small, but Dr. Fleming had found it fairly large. This was probably owing to the comparative smallness of the transformers used, for in very large transformers such as he assumed were employed, the magnetic leakage to which he (Mr. Swinburne) attributed any rise caused by the transformer was relatively small. He ventured to think that Dr. Fleming had made a mistake in imagining the self-induction of the primary of a transformer an important factor in the phenomenon, for it could only act as a choking coil in consequence of the magnetic leakage which existed. Part of the increased pressure was due to the "drop" in the transformer, and in designing transformers this drop should always be determined and allowed for. After giving a formula expressing the drop in open-circuit transformers, he said that Prof. Ayrton had found that there was a rise of pressure due to the transformer, and had also stated that a rise occurred in the mains themselves; this he (Mr. Swinburne) had shown to be impossible. He hoped Dr. Fleming would go into the subject of transformers more fully, taking the waste field into account. Unfortunately, this leakage was at present considerable, but he thought it would soon be reduced.

Prof. Ayrton said he took great interest in Dr. Fleming's paper because it confirmed many results brought forward by Dr. Sumpner and himself in a paper recently read before the Physical Society. Referring to paragraph six of Dr. Fleming's paper, he said that the general statements about Mr. Blakesley's conclusions and those of the author were rather confusing, for Mr. Blakesley's results were only applicable to shunted condensers, whereas those of Dr. Fleming referred to unshunted condensers. In treating of resonance, the author, he said, concluded that there was only a narrow range of capacity within which the pressure at the condenser may be much greater than that at the machine. This conclusion resulted from his having chosen a coil having a resistance of only 10 ohms and a very large self-induction of 200 secohms (henrys). As a matter of fact, resonance effects spread over a large range, and in practice it was impossible to get a coil with such a large time-constant as Dr. Fleming had imagined. The pressure at the condenser could therefore never be 100 or 1,000 times that at the alternator, five or 10 times being about the practical limit. The experiments made by Messrs. Siemens Brothers were very interesting, and distinctly proved that the ratio of transformation of a converter varied with capacity. No doubt Mr. Swinburne would say it was all due to leakage, but, nevertheless, the fact that the change existed was certain. In some experiments which Dr. Sumpner and himself had brought before the Physical Society a change of 11 per cent. was observed when the ratio of transformation was only two, and it was then pointed out that with larger ratios the changes would be greater. In the case of the Siemens transformer the ratio increased 32 per cent. Referring to the mathematical equation No. 31 in the paper—viz.,

$$I = \frac{C p}{\sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2}} V_0,$$

he said the matter was greatly simplified by dividing both numerator and denominator by Cp, thereby obtaining

$$I = \frac{V_0}{\sqrt{\left(\frac{1}{C p} - L p\right)^2 + R^2}}.$$

The numerator then became an E.M.F., and the denominator represented ohms, for since R was resistance in ohms $\left(\frac{1}{C p} - L p\right)$ must also be of the order ohms, otherwise they could not be added together. In another place Dr. Fleming had written the equation in practically the same way, but did not prove the equation there given. The proof of (31) was greatly simplified by taking the current as the given element instead of the pressure. For, assuming that $i = I \sin p t$, where I is the maximum value of the current, then in a circuit having resistance, R, and inductance, L, in series with a condenser of capacity, C, the pressure between the ends at any instant was given by

$$V = R i + L \frac{d i}{d t} + \frac{1}{C} \int i \, d t.$$

$$\therefore \quad = R I \sin p t + L p I \cos p t + \frac{I}{C} \int \sin p t \, . \, d t.$$

$$\text{Hence } V = R I \sin p t + \left(L p - \frac{1}{C p}\right) I \cos p t.$$

The form of this expression showed that the phases of the two terms on the right-hand side were in quadrature, hence the maximum value of V could be got by taking the square root of the sum of the squares of the coefficients, and equation (31) followed immediately. This method has also the advantage of introducing no differential equations of the second order, and was very convenient for teaching purposes. Referring to the so-called Ferranti effect, he enquired whether the pressure at the dynamo terminals was observed before the trunk mains were attached. He also took the opportunity of pointing out a mistake he had made in a diagram published in the *Electrician* on January 2, 1891. In this figure the connections were shown wrong, and hence gave the impression that a rise occurred in the part of the circuit representing the mains themselves. Although no rise had been observed, Mr. O. Heaviside had shown that under certain conditions such a rise would take place. He did not think Mr. Swinburne was correct in stating that he (Prof. Ayrton) had ever said there was a rise in the Deptford mains. What he did say was that a voltmeter operated from the distributing mains at London read 100 volts, whilst a similar one actuated from the primary at Deptford read 80 volts, and this statement was now borne out by the figures published by Dr. Fleming.

Mr. Evershed thought neither Mr. Swinburne nor Prof. Ayrton had expressed the true feeling of the meeting towards Dr. Fleming for bringing forward such a valuable paper. Although Mr. Swinburne had conceived the true explanation of why a rise of pressure should occur when the Ferranti trunk mains were connected to the transformers, he had not made himself clear, and his explanation was not complete, for the cause of the change in the ratio of transformation had not been given. The phenomena were, he thought, best considered separately. Taking the case of the general rise of pressure in both circuits by putting on a condenser, he pointed out that when the E.M.F. of the alternator was a maximum the condenser was fully charged, and no current passing into it, whereas the condenser current was a maximum when the E.M.F. was zero. Now, the E.M.F. of the alternator being zero when the armature coils are directly opposite the magnet poles, the condenser current attained its maximum at the instant when the coils were in a favourable position for influencing the fields. A little consideration, he said, showed that this current would strengthen the fields, and hence cause a greater E.M.F., and a rise would therefore be observed in both circuits. To explain the change in the ratio of transformation he considered a 1 to 1 transformer having considerable magnetic leakage between the two coils. Just as was shown in the previous case, when a condenser was put across the secondary mains, the condenser current would be a maximum when the secondary E.M.F. was zero. But zero E.M.F. meant maximum induction in the iron, hence the condenser current being in step with the induction would increase the induction in the iron; but, owing to leakage, this increase would affect the E.M.F. of the secondary more than that of the primary, and hence change the ratio of transformation. It was, therefore, quite possible to neutralise the "drop" in transformers by putting on condensers, and had Mr. Ferranti designed his transformer to give a greater

GLASGOW ELECTRIC LIGHTING.

The following discussion on the recommendations of the sub-committee on electric lighting arose at a meeting of the Town Council held a day or two ago.

The Sub-Committee recommended as follows: "1. That the Town Council should in the meantime, instead of transferring their powers to any outside person or company, themselves undertake the laying down of the necessary work and plant for generating and supplying electricity for private and public lighting within the compulsory or central area of the city, under such professional advice and superintendence as may be deemed requisite or expedient. 2. That the system of supply, mode of distribution, and other details connected with the proposed installation should, as far as may be found expedient, be in accordance with the reports obtained from Mr. Crompton, Prof. Jamieson, and Sir William Thomson. 3. That, if the recommendations now made are approved, the matter be remitted back to the Gas Committee to arrange for acquiring a suitable site for the erection of a central supply station and to take all other necessary steps for carrying out the proposed works. As will be seen from the report by Mr. Crompton, the cost of putting down the plant requisite for supplying 11,000 16-c.p. lamps (exclusive of cost of sites for central station and sub-station) is estimated at £51,307."

Mr. Ure, in moving the adoption of the minutes, explained the recommendations of the committee at length. With regard to the first one, the sub-committee, after full consideration of the whole matter, came to the unanimous finding that the Council ought to undertake the supply of electric lighting to the citizens. They had comparatively little experience to guide them in forming this resolution. It was difficult to get at the financial outcome of private companies. The only Corporation that had for any length of time taken up the matter for themselves was Bradford, where there had been in operation for a year and a half an installation for private lighting only, equal to about one-half of what would probably be required for private lighting within the compulsory area in Glasgow. The deputation that visited Bradford found that there seemed to be in the minds of those whom they met no serious difficulty in the way of a town council carrying on an undertaking such as this. As to the financial results, it had been necessary in commencing such an undertaking to expend a very considerable amount of capital. In the first few months in Bradford they showed a loss of £2,127. In that sum, however, was included £1,086 paid as a sinking fund. The capital expended was about £31,000. In Bradford the electric light was popular with customers. During the last six months the loss amounted to £315, and it was expected that in the course of a year the undertaking would be carried on at a profit. The Bradford people commenced selling electricity at 5d. per unit, but they found that they had to raise the price to 6d., which made the corresponding price, as compared with gas, about 5s. per 1,000. With regard to the second recommendation, Mr. Ure explained that, although the committee had consulted Mr. Crompton, they were not bound to take his system or engage him. Mr. Ure indicated the principal considerations which had influenced the committee in asking Sir William Thomson for his advice. These considerations were—first, as to the safest methods for supplying the city with electricity; and, secondly, as to economy consistently with efficiency. Sir William had not the slightest hesitation in replying to both these questions, and he recommended strongly that the low-tension system was the best for the city. That was the substantial finding of the three reports the committee had to lay before the Town Council. No doubt there were other systems and advocates of other systems, but the low-tension was recommended by the committee as having been recommended by these gentlemen. If the Council approved of the two first recommendations of the committee they would doubtless adopt the other, and remit to the committee to carry out their recommendations. It was a very important question, and he hoped gentlemen would recognise the importance of it. This work, if gone on with at all, must be gone on with energetically. Unless they did so they would have companies starting and making it a difficult matter for them to go on without complications. He trusted, therefore, that the Council would adopt these recommendations.

Mr. M'Laren seconded the motion. In company with Mr. Ure, he had had the opportunity on Monday last of witnessing the latest installation at Notting Hill, London. This installation was first in operation on the previous Saturday, and the result of Monday's operation was to confirm his belief as to the wisdom of the recommendation of the committee with regard to the low-tension system. All the appliances were the same as those now recommended. The wires of the London company were laid underground on the method recommended by Sir William Thomson, and Mr. M'Laren believed that in this way safety would best be secured. The only difficulty was this, that since this report was made out and submitted to the Council at last meeting a complication had arisen. The Electric Lighting Committee had the idea that all wires at present in existence over the streets must be taken down within two years. There were, however, doubts in their minds, and they had an interview with the Board of Trade in regard to this matter, and to his mind the answer given by the Board of Trade rather complicated the position. That answer brought out this, that the parties who at present supplied the electric light to the city with overhead wires were not compelled to take the wires down and place them underground. They had full power from the Board of Trade to carry on what they were doing just now. The matter was so complicated that he thought very strongly they ought to try to come to terms with Messrs. Muir, Mavor, and Coulson. To his mind that firm could enter into competition, notwithstanding that the Corporation possessed a provisional order, and imagined that no one could compete.

Bailie M'Farlane asked whether Sir William Thomson was the electrical adviser of Messrs. Muir, Mavor, and Coulson.

Mr. Ure said Sir William Thomson was the adviser of that company, but when asked whether he would advise the high-tension system to be adopted by the Corporation, he was decidedly opposed to it.

Mr. Richmond said that Sir William Thomson had reported in favour of the low-tension direct-current system, and more especially over the compulsory area. He wished to know whether Sir William had given a clear recommendation as to the system which he would recommend for other districts of the city at some distance from the area of compulsory supply.

Mr. Ure replied that Sir William recommended the extension of the low-tension system all through the city. The three-wire system he recommended in preference to two wires, because it might be easier of extension.

Mr. J. U. Primrose said he had studied all the reports of the committee, and all materials put before the Council. He had read the reports of the various experts, and he was confirmed in the belief that they were only justified in adopting the first of the three recommendations of the Gas Committee. He moved as an amendment that only the first recommendation be accepted. He felt that the Council had not yet emerged from the state of mere experiment, and that they had no information put into their hands by experts sufficiently assuring to justify the Corporation in accepting the whole programme recommended to them by the Gas Committee. It was proposed to remit to them the negotiations with Messrs. Muir, Mavor, and Coulson. In this matter a very much wider horizon must be viewed than the limited horizon of the mere present money value of that concern. The committee must recognise the fact that Messrs. Muir, Mavor, and Coulson entered the field and supplied the community with the electric light, the Corporation among the number, at a time when the whole question was involved in doubt. In coming to a bargain with them, the Corporation must keep the facts of the case clearly in view, and, above all, he, for one, must deprecate the insistance on the acceptance of any bargain by that firm that would amount to anything approaching confiscation. Let the Corporation be reasonably generous, if necessary. These men entered the field in its earlier stages. The Corporation accepted the convenience of getting a supply from them, and they should be the last parties to drive a hard and what might seem to be an unreasonable bargain. He would point to the early history of the Corporation, when in acquiring works in another sphere, but of a kindred character, they had had to pay sweetly for getting into their hands existing concerns.

Mr. Shearer said he believed the Gas Committee were acting in a right way towards the citizens in recommending as they had done. At the same time the feeling of the Council was strongly against any man's property being confiscated. Knowing the existence of that feeling, and after what they had heard incidentally from Bailie M'Laren, he had no fear but that Mr. Primrose's ideas would be carried out, and if Bailie M'Laren would only indicate that Messrs. Muir, Mavor, and Coulson's property would not be confiscated, he would refrain from seconding the amendment.

Bailie Paton said Mr. Primrose must bear in mind that the sub-committee had spent a large share of time and a great amount of effort in getting the information which was now presented to the Council. They had taken every opportunity of getting all the information, and the latest information, that could be got. The conclusion they had come to was one from which in general they would not be easily moved—that was to say, that the three-wire low-tension system was that which should be adopted in the compulsory area the Council were now asked to deal with. The powers asked in the second recommendation were extremely general. They knew quite well that at present the Council did not want to be committed, nor did the sub-committee wish to be specially committed, to any particular principle of carrying out the work. As to Messrs. Muir, Mavor, and Coulson, the sub-committee were not wishful to confiscate any man's property. They were anxious to deal fairly and honourably with Messrs. Muir, Mavor, and Coulson or any other party, but in a delicate matter of this kind power must be given to the sub-committee if they were to deal with it at all. They would report in due course, and if the Council thought they were acting unfairly the opportunity of correction would be afforded.

Mr. Primrose said that, in view of the statement made by Bailie Paton with regard to the spirit dominating the committee, he would withdraw his amendment.

Mr. Colquhoun said he was sorry that Mr. Primrose had withdrawn the amendment, which he was just on the point of rising to second. If necessary, he was prepared to move the amendment which Mr. Primrose had abandoned, because he held they were not in a position to go further than affirm the general principle that the Town Council should keep the electric lighting in its own hands. He had given these reports and recommendations of the sub-committee very careful attention, and he quite concurred with them in thinking that Glasgow would make a mistake if it parted with the control of its electric light. But when the sub-committee asked the Town Council to commit itself to this low-tension system alone, he thought they were taking a course which with their present information would not be advisable. What was the position of the Council in this matter? They were bound to provide electric light for the whole city—not merely for the compulsory area. Within the compulsory area they were bound to provide electric light within a period of two years. But the electric lighting order went beyond that, and said that any six ratepayers in any portion of the city could come to the Corporation and demand a supply of electric light. Now, if they were under obligation to supply electric light to any six ratepayers in any outlying part of the city, what became of the suggestion that they should have a nice little compact area in the centre, which was to be worked on the low-tension principle? Because what they would undoubtedly have to face in the near future was that they would have a demand from outlying ratepayers. They had received a report from Mr. Crompton, who they knew was a great authority on the low-tension principle. With that report he (Mr. Colquhoun) would find no fault if they were dealing with the compulsory area alone; but that was not the position. Prof. Jamieson did not in express terms in any part of his report say that if the whole city of Glasgow were to call upon them to supply electricity the low-tension system was the best. His report was a balancing of the conveniences and inconveniences of the rival systems. He avoided committing himself to what was best for the city as a whole. Sir William Thomson gave as his opinion that for the compulsory district alone the low-tension system was the best. But he had received a statement from Messrs. Muir, Mavor, and Coulson, in which he was a little surprised to find certain statements in a report by Sir Wm. Thomson. Reading that report in the light of the recommendations of the sub-committee, he was amazed that Sir William Thomson had allowed a report to get into the hands of the sub-committee of such an indefinite and nebulous character. In this report he found a series of questions put to Sir William Thomson and Sir William's answers. The first question put was this: "Is the system of high-tension distribution, hitherto adopted in Glasgow by this company, the best for meeting the demand from isolated consumers scattered over a large area?" That was putting in a precise form the question which he (Mr. Colquhoun) would desire to put to Sir William Thomson, and his reply was as follows: "The system of high-tension distribution hitherto adopted in Glasgow by your company is the best for meeting the demand from isolated consumers scattered over a large area. No other system hitherto either practised or proposed is adapted to supply this kind of demand." He confessed that he was a little surprised when he found that Mr. Ure, in face of this document, gravely asked the Council to commit themselves to the principle of low tension alone. From the remarks of Bailie Paton he gathered that they would have a low-tension station to meet the demand that would arise within the compulsory area. But did anyone suppose that the electric light would be called for by the citizens in little compact areas? The thing was inconceivable. The demand would come from the north, south, east, and west, not from any particular area. And was it to be contended that they were to be at the expense of putting down a low-tension station for half a dozen people in the Cowcaddone or on the south side? The thing was monstrous in the light of Sir Wm. Thomson's report to Messrs. Muir, Mavor, and Coulson. He therefore moved that the minute be sent back to the sub-committee for further investigation, and that they should confine themselves to confirming the principle that they should keep the electric light exclusively in their own hands.

Mr. Thomson seconded Mr. Colquhoun's amendment.

Mr. Chisholm said Mr. Colquhoun had indulged in some strong language in regard to the report of the committee which a consideration of the facts would not warrant. This recommendation applied exclusively to the compulsory or central area of the city.

Mr. Colquhoun: Allow me to interject a remark. In the first resolution, although we in express terms confine ourselves to the compulsory area, that is practically declaring that we are to keep the electric lighting of the city in our own hands, because the compulsory clauses of the Corporation order are merely subsidiary to the general principle that the whole of the electric lighting shall be in the hands of the Corporation.

Mr. Chisholm said he did not think there would be the slightest difference of opinion in the Council that they ought to keep the electric lighting of the city in their own hands. But meanwhile the recommendation applied only to the central area of the city. Mr. Colquhoun imagined that from all quarters of the city there would be demands for electric light. But Mr. Colquhoun had not apprehended the precise point. The electric lighting order provided that every applicant for electric light should, along with his application, send an undertaking to provide 20 per cent. per annum of the entire cost of the mains leading up to the premises of the Corporation—that was to say, that the applicant himself was in five years to pay the entire cost of it. In view of that fact, did Bailie Colquhoun imagine that the Council would be deluged with applications to such an extent that it would be impossible to supply them? He thought that one fact was a sufficient safeguard that the Council would not be deluged with applications. With regard to the second recommendation, it was there provided that the system of supply, the mode of distribution, and other details connected with the proposed installation, as far as might be found expedient, should be such that if, after having provided the central area with a supply of low-tension it should be found desirable to supply any applicant outside with any other system, the recommendation left them abundance of latitude to do so.

Mr. Richmond said that the committee who had charge of this matter had done their work well. They had had an enormous amount of labour, and they had given the Council a very good report. At the same time he had some doubt as to whether the recommendation was a safe one. Mr. Chisholm had pointed to the fact that they only confined themselves to this system in respect of the compulsory supply area. Nobody who had studied the subject of electric lighting but could come to the opinion that that was the correct course so far as that area was concerned. But Sir William Thomson, in his reply to Messrs. Muir, Mavor, and Coulson, pointed out that for the outlying districts this system was not the proper one. Why, then, should the Council tie their hands now with regard to the outlying districts by adopting this particular system, thereby making it prohibitory for those districts to get a supply? While they must conserve the interests of the Corporation, they were there also as representatives of the ratepayers, and they must conserve the interests of the outlying districts.

Mr. Ure said that it was only the question of the statutory area that was before them. If they were going to deal with any other area it would come before the Town Council.

Mr. Richmond said that if they confined themselves exclusively to the compulsory area, then he had nothing more to say.

Mr. Ure said that there was no wish to prevent the extension of electric lighting. What they had to deal with just now was exclusively the statutory area. With regard to Messrs. Muir, Mavor, and Coulson, the committee fully realised the circumstances in which they were, and would try to do justice to them if they possibly could. The committee asked that this should be remitted back to them. No one wished to oppress the company, which had done good service both to the Corporation and to the citizens.

The Council then divided, when there voted for the motion—Bailies Stevenson, J. H. Martin, Morrin, Paton, Graham, Bowman, and Brechin; the Deacon-Convener, Treasurer Watson, Messrs. Alexander, Campbell, Chisholm, Crawford, Dickson, Mitchell, Murdoch, M'Kellar, M'Laren, Macpherson, M'Phue, Neil, Neilson, Osborne, Parnie, Richmond, Shearer, Ure, Waddell, Walter Wilson, and William Wilson—30. For the amendment—Bailies M'Lennan and Macfarlane, Messrs. Bilsland, Colquhoun, Guthrie, Thomson, and Wallace—7.

LEGAL INTELLIGENCE.

THE NEW TELEPHONE COMPANY.

Winding-up Proceedings to be Stayed.

In the Courts last week, Mr. Higgins, Q.C., applied to Mr. Justice North under Section 29 of the Companies Act, 1862, for an order staying the proceedings in the winding up of this company. He said it was an application not often made, but he did not think there was any difficulty about it, the liquidation in this case being under the supervision of the Court. The applicants were two contributories, and the liquidator was the respondent. The whole of the debts proved amounted to £5,223. 8s. 3d., the principal debts being £4,000 in respect of certain patents, due to Prof. Silvanus Thompson and others, but these had now been released, and Prof. Thompson was one of the two petitioners. This only left £1,173. 17s. 7d., which would be paid in full, there being one asset, and, in fact, the only one, which might be of considerable value if the company went on, but which would be utterly worthless if the company were wound up, as it consisted of a license from a public body. All the shareholders but four had already signified their consent to the application. One thousand pounds had already been provided for paying the debts, but, of course, the small balance would have to be found so that the creditors might be satisfied, and he should ask that the order be made, not to be drawn up until an affidavit was produced by the liquidator showing that all the debts had been discharged.

His **Lordship** said he would make the order when such an affidavit was produced. The petition need not be mentioned again.

JOHNSON v. RADCLYFFE.

Claim for Electric Lighting.

In the Westminster County Court on Friday, the case of Johnson v. Radclyffe came on for hearing before his Honour Judge Bayley by way of a remitted action from the High Court, in which the plaintiffs, Messrs. Johnson and Co., who are electrical engineers carrying on business at High-street, Staines, sought to recover a balance of account of £44. 9s. 6d. for work done to the order of the defendant, Mr. Raymond Radclyffe, the editor of the *St. Stephens' Review*, residing at Princes-mansions, Victoria-street, Westminster. The defendant had paid a sum of £75 on account, but he disputed the balance now claimed on the ground that some of the work was done, not for him, but for Colonel North.

It appeared from the opening statement of counsel for the plaintiff, that some time ago the defendant gave an order to the plaintiff to fit up the electric light on board his house-boat, called "The Golden Grasshopper," and he expressed very great satisfaction with the manner in which the work was carried out. Subsequently he gave a further order for the light to be fitted up at his private residence at Princes-mansions, and the work also was carried out in due course, but the defendant said he would not be supplied with current from the company who were already supplying the building as he did not consider their light was satisfactory, and would therefore prefer to get the supply laid on from some other company. The plaintiff arranged for that to be done, and additional expense was thereby rendered necessary. The whole of the work had been completed, and there now remained due a balance, £44. 9s. 6d. The story the defendant was going to set up was that Colonel North was liable for part of the work, and that there was an item charged for laying on the current for which he was not liable.

The plaintiff was called, and gave evidence as to receiving instructions from the defendant as to what he wanted done, and a price was in each case agreed upon before the work was commenced. He most distinctly denied that Colonel North's name was ever mentioned, and from first to last he looked to the defendant for payment, and to no one else. There was no truth in the suggestion that the estimate which was given for the work was to include the cost of laying on of current by a company which did not already supply the building. As a matter of fact, there was nothing whatever to have prevented the defendant from having the light the moment the fittings were completed, had he chosen to have been supplied with current by the company which was already supplying some portions of the building, but he wanted the services of another company, and that was what caused the delay.

For the defence Mr. Radclyffe was called, and said the order for Princes-mansions was given on the distinct understanding that the plaintiff was to make arrangements for a supply of current from some company other than the one which was supplying the building, but he had failed to do so, and consequently no light was obtained and the fittings were for a time rendered useless. With regard to the house-boat, the order was given by him, but it was given on behalf of Colonel North, and the plaintiff was made aware of the circumstances.

The wife of the defendant was also called, and corroborated her husband's story. The order for the work on the house-boat was given on behalf of Colonel North, and her husband was not to be liable for it. The work at Princes-mansions was rendered useless owing to the fact that the plaintiff failed to carry out the terms of the order.

After hearing the whole of the evidence His **Honour** said there was not the slightest doubt in his mind that the defendant, and he only, was liable to pay this money. It had been alleged that Colonel North was to pay for some portion of it, but that was distinctly denied by the plaintiff, who was very clear as to what the terms of the order were. If Colonel North was to be liable for any part of the work, it was the duty of the defendant to have brought that fact clearly to the mind of the plaintiff before the work was done, but it was clear that he did not do so. As to the work at Princes-mansions, he (the Judge) believed that plaintiff had fully carried out his contract, therefore judgment would be for the plaintiff for the full amount of his claim and costs on the scale.

COMPANIES' MEETINGS.

CHINA AND JAPAN TELEPHONE COMPANY.

The eighth ordinary general meeting of this Company was held at the registered office, 14, Austinfriars, on Tuesday.

The report of the Directors for the year ending December 31, 1890, stated that the revenue account, after charging debenture interest and £137. 17s. 6d. in connection with the removal of the exchange at Shanghai to new premises, showed an amount to credit of £815. 16s. 11d., which had been transferred to profit and loss account. Including the sum of £363. 16s. 4d. brought forward from 1889, this account showed an amount of £1,179. 13s. 3d. to credit, from which the Directors proposed to write off the sum of £338. 0s. 10d. in reduction of capital expenditure, carrying forward the balance. The £5,000 of 7 per cent. debentures, which fell due on January 1 last, and which are held by the Oriental Telephone Company, had been renewed with that company's consent for another term of five years. The Directors regretted to have to record the death, on December 6, after a long illness, of Mr. H. G. Erichsen, the chairman of the Company, and representative in London of the Great Northern Telegraph Company. The retiring Director was Mr. Thomas Lloyd, who, being eligible, offered himself for re-election. The auditors, Messrs. Price, Waterhouse, and Co., also retired, and offered themselves for re-election.

The **Chairman** (Mr. H. Grewing), in moving the adoption of the report, said that the general result as compared with last year was rather better. The reason for the expenditure of £140 was the necessity of the removal of the Shanghai exchange for sanitary reasons to other premises. There operations were limited at present until the long-expected opening up of China to the Western civilisation, to two cities, Shanghai and Hong Kong, which were, indeed, the only places in which, so far, it is possible to introduce the telephone, as they are the only towns with any number of European inhabitants. Any immediate extension is thus limited. The present exchanges continue to receive every possible attention, and may be said to be capable of some further development. The Directors have considered it right to carry forward the debentures held by the Oriental Telephone Company which fell due last year, but only for another five years, and they will therefore fall due again in 1895. The Directors think it well to make some provision of capital, as they are continually requiring some funds for further extension and for the development of their sales business, and as no provision had been made for that department they had to fall back on revenue. They had to regret the death of their late chairman, Mr. H. G. Erichsen, who had given much care and attention to the Company.

The report was adopted, and Mr. Thomas Lloyd, who retired by rotation, was re-elected. Messrs. Price, Waterhouse, and Co. were re-elected at a remuneration of 10 guineas, and the Directors' fees were settled at 200 guineas, to be divided as they think fit.

The accounts show the interest on the 7 per cent. debentures (£350) paid. The subscriptions and rentals came to £3,540, and working expenses £2,164, and expenses in London £121, leaving, with the other expenses, £815 profit. The balance forward was £573, which, less the £210 Directors and £338 written off for depreciation of plant, left £841 to be carried forward as working capital. No dividend on ordinary shares was declared.

COMPANIES' REPORTS.

ELECTRIC AND GENERAL INVESTMENT COMPANY, LIMITED.

Directors: His Grace the Duke of Marlborough (chairman); the Right Hon. Lord Cloncurry; Jos. B. Braithwaite, jun., Esq.; Emile Garcke, Esq.; George Herring, Esq.; B. H. Van Tromp, Esq.

The Directors beg to submit herewith a statement of the accounts for the period ended the 31st May, 1891, showing a net profit of £2,592. 6s. available for distribution, which the Directors recommend should be appropriated as follows: That a dividend of 10 per cent., together with a bonus of 12s. 6d. per cent., be paid on the capital paid up on the ordinary shares; that £266. 10s. 9d. be placed to reserve; that a dividend of £1. 5s be paid on each founders' share; that £59. 4s. 6d. additional remuneration be paid to the Directors, in accordance with the articles of association; and that £16. 10s. 9d. be carried forward, in equal moieties, on account of the ordinary and founders' shares. A large number of proposals of various kinds have been submitted to the Board, all of which have received careful consideration, and such as seemed suitable for this Company to take up have been fully investigated, but in view of the great financial depression which has existed for some time past the Directors have had to proceed with great caution. The Board have now certain important matters in hand which they have every reason to hope will be successfully dealt with and prove remunerative. The auditors (Messrs. Rait and Kearton) offer themselves for re-election.

BALANCE-SHEET AT 31ST MAY, 1891.

Dr.		£	s.	d.
Capital authorised—£200,000 in 39,900 ordinary shares of £5 each, and 100 founders' shares of £5 each.				
Capital subscribed—20,000 ordinary shares, 100 founders' shares.				
Capital called up—				
£1 per share on 20,000 ordinary	£20,000			
£5 per share on 100 founders'	500			
		20,500	0	0
Sundry creditors		793	4	8
Balance profit and loss account		2,592	6	0
		£23,885	10	8

Cr.	£	s.	d.
Loans against consols	10,000	0	0
Investments at market price	1,500	0	0
Preliminary expenses	726	0	1
Sundry debtors	596	15	0
Cash on deposit at bankers	10,000	0	0
Cash on current account at bankers	1,062	15	7
	£23,885	10	8

PROFIT AND LOSS ACCOUNT FOR THE PERIOD ENDED 31ST MAY, 1891.

Dr.				£	s.	d.
General charges, including rent of offices, directors' fees, general expenses, fees for reports, and legal charges and advertising, etc.				1,069	17	4
Proposed appropriation of balance—						
Dividend at the rate of 10 per cent. on the ordinary shares	£2,000	0	0			
Additional remuneration to Directors in accordance with the articles of association	59	4	6			
Payment to reserve fund	266	10	9			
Dividend of £1. 5s. on founders' shares	125	0	0			
Bonus of 12s. 6d. per cent. on paid-up capital	125	0	0			
Balance carried forward on account of ordinary shares	8	5	5			
Balance carried forward on account of founders' shares	8	5	4			
				2,592	6	0
				£3,662	3	4

Cr.	£	s.	d.
Interest, commissions, and sundry profits	3,662	3	4
	£3,662	3	4

CITY NOTES.

Western Brazilian Telegraph Company.—The receipts for the week ended June 5 were £4,546.

Commercial Cable Company.—A quarterly dividend of 1¾ per cent. upon the outstanding stock is announced, payable July 1.

City and South London Railway.—The receipts for the week ending June 6 were £776; those for the previous week (May 30) being £768. The receipts for the four weeks ending May 30 amounted to £2,896.

Brazilian Submarine Telegraph Company.—An interim dividend of 5s. per share, tax free, for the quarter ended March 31 has been declared, payable on the 24th inst. The traffic receipts of this Company for the week ended June 5 were £5,798.

NEW COMPANIES REGISTERED.

Albert Electric Lighting Company, Limited.—Registered by Bonner, Wright, Thompson, and Co., 165, Fenchurch-street, E.C., with a capital of £10,000 in £5 shares. Object: to carry on the business of electricians, mechanical engineers, etc. With slight modifications, the regulations contained in Table A apply.

Aurora Electric Lighting and Distribution Company, Limited. Registered by F. Ridley, 52, Leadenhall-street, E.C., with a capital of £25,000 in £1 shares. Object: to establish, carry on, and develop in the United Kingdom and abroad the business of an electric light and power company in all its branches. The first subscribers are:

	Shares.
R. H. J. Tilley, Romford, Essex	5
W. F. Latorre, Romford, Essex	5
E. F. Le Sonef, 54, New Broad-street, E.C.	9
F. J. Latorre, Albert Villa, Mawney's-road, Romford	5
D. M'Gill, 118, Cannon-street, E.C.	5
W. Graham, 13, Crutchedfriars, E.C.	1
H. J. Le Sonef, Woodford Green, Essex	5

There shall not be less than three nor more than seven Directors. The first are to be appointed by the signatories to the memorandum of association. Qualification, £25. Remuneration, £100 per annum, divisible.

Bournemouth and District Electric Supply Company, Limited.—Registered by Renshaws, 2, Suffolk-lane, E.C., with a capital of £50,000 in £5 shares. Object: to acquire the right of supplying electricity for light or power, heretofore carried on at Bournemouth by the Brush Electrical Engineering Company, Limited, in accordance with an agreement expressed to be made between the Brush Electrical Company of the one part and the Company of the other part, and to carry on the business of electrical engineering in all its branches. The first subscribers are:

	Shares.
J. A. Horker, Kirkleatham, Boscombe	1
L. E. Scarth, Keverstone, Bournemouth	1
A. H. Sanderson, Maywood, Bournemouth	1
G. J. Piercy, Bournemouth	1
H. U. Wollaston, 9, Pine Tree-glen, Bournemouth	1
A. E. F. Francis, 9, Observer-chambers, Bournemouth	1
D. W. Preston, Penryn, Bournemouth	1

There shall not be less than three nor more than seven Directors. The first are John Fair, William Fisher, D. M. Fox, J. Atkinson Hosker, G. J. Piercy, A. H. Sanderson, and L. Scarth. Qualification, 20 shares. Remuneration to be determined in general meeting.

PROVISIONAL PATENTS, 1891.

JUNE 1.

9155. **Means for preventing the interference of induction currents of the earth and line wires in telephonic and other electric circuits.** Robert Henelaide Courtenay, 717, Wandsworth-road, London.

9190. **An improved electric clock.** Samuel John Davies, 74, Leadenhall-street, London.

9227. **Improvements in telephones.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany.)

9241. **Improvements in or appertaining to electric railways.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Knox Harding, United States.) (Complete specification.)

9245. **Improvements in telegraphic apparatus.** Anton Linhart and Conrad Seitz, 6, Lord-street, Liverpool.

9249. **Improvements in electromagnets for holding tools, lamps, brackets, or other articles, and for telegraphic and other apparatus.** Frederick John Rowan and William McWhirter, 87, St, Vincent-street, Glasgow.

JUNE 2.

9291. **Improvements in electric arc lamps.** Albert Edwin Bishop, 8, Quality-court, London.

9299. **Improvements in apparatus for electrically controlling and registering the movements of keys in connection with railway block instruments, and for other purposes.** William Robert Sykes, sen., 2, Great George-street, Westminster, London.

JUNE 3.

9403. **Improvements in electrically insulating appliances, known as "suspensions."** James Raeburn, jun., 263, Argyle-street, Glasgow.

9423. **An improved holder for electric incandescent lamps.** Hubert Henry Grenfell, 45, Southampton-buildings, London.

9435. **An electrical transformer.** Edward Friedrich Heinrich Hermann Lauckert, 28, Southampton-buildings, London. (Complete specification.)

9436. **An electrical transformer.** Alfred David Williamson, 28, Southampton-buildings, London. (Complete specification.

9437. **Improvements in compasses with electrical appliances for signalling and recording the course and speed of a ship, also partly applicable to other purposes.** Joseph von Peichl, 28, Southampton-buildings, London.

JUNE 4.

9462. **An electrostatic switch and phase indicator.** Alfred Upton Alcock, 70, Market-street, Manchester. (Complete specification.)

9507. **An improved electric stop motion for engines.** Charles Amos Dayton, Monument-chambers, King William-street, London.

9522. **Improvements in alternating currents in electromagnetic motors.** William Stanley, jun., and John Forrest Kelly, 45, Southampton-buildings, London. (Complete specification.)

9524. **Improvements in methods of and apparatus for preventing the interference with speech on telephone circuits by induced and other currents.** William Stanley, jun., and John Forrest Kelly, 45, Southampton-buildings, London. (Complete specification.)

JUNE 5.

9555. **Improvements in carbons or electrodes for arc or other electric lamps.** James Eglinton Anderson Gwynne, 11, Furnival-street, London.

JUNE 6.

9593. **Advertising and illuminating by electric current.** James Tyrrell Newell, 56, Brymer-road, Camberwell, London.

9627. **Improvements in thermo-electric batteries.** Charles Denton Abel, 28, Southampton-buildings, London. (Robert Jacob Gülcher and the firm of Julius Pintsch, Germany.) (Complete specification.)

9628. **Improvements in or connected with negative elements (positive electrodes in charging secondary cells) of voltaic batteries.** Desmond Gerald FitzGerald, 47, Lincoln's-inn-fields, London.

9629. **Improvements in or relating to the negative elements (positive electrodes in charging secondary cells) of voltaic batteries.** Desmond Gerald FitzGerald, 47, Lincoln's-inn-fields, London.

9637. **An improved automatic electric control or cut-out.** Henry Alabaster and Tom Ernest Gatehouse, 1, Queen Victoria-street, London.

9639. **The better insulation of electrical conductors, and to obtain immunity from fire from the use of such conductors.** Walter Charles Lovelace, 159, Cromwell-road, South Kensington, London.

9642. **Improvements in and relating to electric lamps or lighting apparatus.** Hugh Watt, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1890.

7540. **Electric arc lamps.** Wise (La Société Japy frères et Cie.). 8d.

9130. **Regulating electric currents.** Heap and Sharp. 8d.

10252. **Electric railways.** Bayly (Evans). 8d.

10768. **Electric lamp shades.** Munro. 4d.

10857. **Electric wire coverings.** Munro. 4d.

10981. **"Arc" lamps.** Warburton. 8d.

11042. **Electric thermometers, etc.** Gooch and others. 8d.

11052. **Telegraph receivers.** Langdon-Davies. 11d.

20936. **Electrical signalling.** Wyckoff. 6d.

1891.

3357. **Vacuum pumps for exhausting incandescent electric lamps.** Lake (Berrenberg). 8d.

5135. **Electric motors.** Southard. 8d.

5192. **Electric clocks.** Scales. 8d.

5547. **Electrolytic decomposition.** Kellner. 8d.

5595. **Electric heating apparatus.** Dewey. 8d.

6072. **Electro-heating apparatus.** Carpenter. 6d.

6292. **Electric insulator.** Miller. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	1½
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9½
London Electric Supply	5	2¼
Swan United	3½	4½
St. James'	—	6½
National Telephone	5	4⅞
Electric Construction	10	7¼
Westminster Electric	—	4¾

NOTES.

French Telephones.—A telephone line between Paris and Amiens was opened on Tuesday.

Fleetwood.—The Fleetwood Commissioners are still considering the question of electric light.

Birmingham.—The reconstructed Grand Hotel at Birmingham has been lighted with electric light.

Gearless Motors.—The electric railway at Williamsport, Pennsylvania, is to be equipped with 30 Westinghouse gearless motors.

Dover.—As will be seen elsewhere, tenders are invited for the erection and maintenance of a central electric station at Dover by July 10 next.

Cardiff.—The Bill for the Cardiff provisional order has passed through the committee stage, and will be reported in due course for the third reading.

Newcastle.—The Newcastle Electric Lighting Bill, having passed committee stage unopposed, will go on for third reading in the House of Commons.

Overhead Wires Bill.—On Monday, in the House of Commons the Lords' amendments to the London Overhead Wires Bill were considered and agreed to.

Cleckheaton Town Hall.—The Cleckheaton Local Board have accepted the tender of Messrs. Holmes and Co., of Newcastle, for lighting the town hall with electricity.

Electric Railways.—This evening Mr. J. H. Gurney will read a paper before the Polytechnic Electrical Engineering Society dealing with the City and South London Electric Railway.

Finchley.—It was stated at the Finchley Local Board meeting that the cost of the proposed provisional order would be about £50, but this would be increased if there were opposition.

Oil Tanks Struck by Lightning.—At Colegrove, in the oil region, two immense tanks were struck by lightning last week. The oil caught fire, the blaze spreading in every direction.

Telephone Patents.—The master patents for the telephone transmitters run out in July. The Postmaster-General is to be asked a question in Parliament as to the licensing of private exchange systems.

Latest about Edison.—A paragraph is telegraphed from America to say that Mr. E. B. Welsh is suing Mr. Edison for a quarter of a million dollars, damage for wrongful appropriation of his electrical inventions.

Rugeley.—Tenders are required for lighting the street lamps for the winter months, for the Rugeley Local Board. For particulars apply to the chairman of the Lighting Committee, Rugeley, to whom tenders should be sent by July 1.

Lightning at Gloucester.—Lightning struck St. Nicholas Church, Gloucester, on Monday, and set fire to the roof. Three firemen climbed up a rod in the interior, and, undaunted by the falling molten lead, hauled up fire extincteurs and put out the flames.

Conversazione.—The President of the Institution of Electrical Engineers and Mrs. Crookes will hold a *conversazione* in the galleries of the Royal Institute of Painters in Water Colours, 191, Piccadilly, on Monday evening, July 6th, from nine to twelve o'clock.

Maidstone.—The Maidstone Highways Committee was deputed to consider the further steps to be taken in reference to an electric lighting order for Maidstone. The town clerk said it would be necessary to take steps at once to make the formal application for an order.

Electric Tramways in Paris.—We learn that at the commencement of next month the Société des Tramways de Paris et du Départment de la Seine will run 20 electrical cars between the Rue Lafayette (near the Opera) and St. Denis. They are to run at a speed of 10 miles an hour.

Society of Arts' Conversazione.—The annual *conversazione* of the Society of Arts, held on Wednesday in the South Kensington Museum, was a brilliant and successful scene. Music was the chief attraction, one of the most successful events being the concert of Old English music in the theatre.

The Edinburgh Tramway Company have pointed out to the Corporation that local bodies may, after 1892, allow the provision for purchase of tram lines to remain in abeyance for seven years, and ask the Corporation to follow this course, leaving the question of method of traction for future arrangement.

Electric Motors for Hairdressers.—The latest idea for hairdressers' shops is an electric motor to drive the shafting which is used for the indiarubber bands for their brushes; on the shaft being mounted at intervals wings or light propellers which create an agreeable ventilation at the same time.

Electric Jaunts.—The Robert Burns Club, one of the most successful of the Scottish institutions in London, is to take their twelfth annual picnic on Saturday. They take a saloon car to Bourne End, and then are to "electrate" in one of the General Electric Traction Company's launches to Medmenham and Henley.

Gainsborough.—The Gainsborough Gas Company declining to reduce the price to the Local Board for the lighting of the town, Mr. Shipman, at Monday's meeting of the Local Board, mentioned electric light. After several of the members had expressed an opinion on the subject, the matter was left with the surveyor.

Aluminium Shades.—Shades for electric lamps spun from aluminium, in one piece, are made by the Electric Supply Company, of Chicago. They are handsome in appearance, and are made in frosted and mottled finish, the inside being of a bright satiny sheen. They do not tarnish, and can be cleaned by wiping with a cloth.

Electrical Fire Calls for Taunton.—Tenders are invited for supply and erection of electrical fire calls, for the Taunton Town Council. Plan, specification, and other information may be obtained at the office of the water works manager, Municipal Buildings, Taunton. Tenders are to be sent by July 6 to the town clerk, Taunton.

Electric Trips.—The General Electric Traction Company have issued a neat little card with the list of their electric trips up stream and down. The launches seem to be very well patronised nowadays, and the energy of Mr. Macpherson in inaugurating commercially this kind of locomotion in the Thames is evidently bearing fruit.

Atlantic Cables to Swansea.—The Commercial Cable Company, recognising the important share of Atlantic cablegrams contributed by Swansea, announces that it has established an office in that town, and leased a special wire to work in connection with its ocean cables, which gives Swansea cabling facilities equal to those of London, Liverpool, and Glasgow.

North Staffordshire Mining Institute.—A paper on low-tension shot-firing was read before this institute by Mr. Winstanley Wallis last week. Of the two systems of electric firing, high and low tension, the author preferred the last, and gave his reasons. This paper will be printed.

Mr. Armstrong read a paper advocating the use of Priestman's oil engines in mines.

Epstein Accumulators.—We learn that the Epstein accumulators lately put on the market by Messrs. Woodhouse and Rawson, Limited, are already being received with considerable favour. An order for some £400 worth of these batteries, we hear, has been given by an important customer who last week carefully tested a set himself at the works.

British Association.—A conference in Edinburgh discussed the British Association meeting in that town for 1892. It was stated that the proceedings might be expected to cost about £1,200, and that Sir Archibald Geikie would be nominated for the Edinburgh meeting. The question whether the time should be August or September was discussed, and Wednesday, September 28, was decided upon.

Artificial Earth Currents.—The instruments registering earth currents in the Royal Observatory at Greenwich have been regularly thrown into vibration at the time the City and South London electric trains begin to run; and, though quite two miles from the nearest earth-plate, there seems little doubt, according to the communication of Mr. William Ellis in *Nature*, that this is the true source of the deviation.

Nottingham.—The electric light at Nottingham seems to hang fire, and correspondents are writing to the local press complaining that the authorities rest firm in their determination neither to set up the light themselves nor permit anyone else to do so. Meanwhile, firms and private individuals are solving the problem for themselves. The largest firm of hosiery manufacturers in the town have long carried out their own installations, and are thinking of extending.

Sales of Plant.—The plant of the Electrical Engineering Corporation at West Drayton will be sold on June 30 and the following days, and at Albert-embankment on July 14. It is with regret, in a new industry, that electrical engineers will see a promising works sold up, especially after plucky attempts and unlucky fires. But the only benefit will be to go and bid the highest prices. Catalogues can be obtained from Mr. F. W. Pixley, 24, Moorgate-street.

Ceiling Rose Switch.—A snap switch fitted in the ceiling rose itself, and sprung off and on by a first and second pull by means of a delicate silk cord and knob, is the type of suspended fitting now much affected in private houses. The Electrical Supply Company, of Chicago, send us some drawings of these kind of fittings made in hard wood and porcelain. One great advantage, of course, is that the difference of cost between the extra switch and the snap switch ceiling rose is saved.

A Writing Telegraph has been recently tested on the Pittsburgh and New York line of the Postal Telegraph Company, it is understood, with considerable success. Longhand script is exactly reproduced, but slight modifications of the letters are necessary, since the style or writing pen should not be lifted from the paper. Short-distance writing telegraph instruments are already used in delivering base-ball scores, but this is thought to be probably the first instance of a message transmitted over such a long distance.

Canterbury.—At the meeting of the Canterbury General Purposes Committee, the town clerk reported that the Electric Light Bill had passed the House of Lords, and had now only to receive Royal assent. Mr. Cross observed that the committee was appointed for a special purpose, and he took it that their labours were now at end, to which the Mayor remarked he hoped they would not lose sight of the fact that they possessed a Bill. The committee probably want a little prompting by electrical engineers.

Electricity in Mining.—The annual meeting of the Chesterfield and Midland Counties Institution of Engineers will be held in University College, Nottingham, on Saturday, June 27, at 3 p.m. The president-elect (Mr. J. A. Longden) will deliver an address from the chair. Various papers on explosives in mines will be open for discussion, and also a paper by Mr. G. E. Smith, on "The S.C.P. Miners' Electric Safety Lamp." A paper will be read or taken as read on "The Low-Tension System of Shot Firing," by Mr. T. M. Winstanley-Wallis, A.I E.E.

London Electric Lighting. — Compliance with Standing Orders is reported upon the following electric light undertakings: Camberwell and Islington Electric Supply Company; the Brush Company (St. Saviour's, Southwark); the Stamford-hill, Tottenham, and Edmonton Electric Supply to light portions of Putney and Wandsworth (the title seems a misnomer); and the Westminster Electric Supply Corporation to light portions of Westminster (Great George-street, Whitehall, and Queen Anne's-gate). We may evidently hope to see the theatre of the Civil Engineers lighted before very much longer.

Cardiff.—At the fortnightly meeting of the Cardiff County Council Lighting Committee, on Tuesday, under the presidency of Alderman Carey, letters were read from several London firms who were prepared, when the committee commenced to apply the electric light for the purposes of public lighting, to tender their services for the work. Mr. Wylie, Cardiff, also intimated his readiness to accept the responsibilities of electrical engineer. It was explained by Mr. Harpur, the surveyor, that the Electric Light Bill had not yet passed the first House, and the correspondence was ordered to be pigeon-holed for reference.

Surge Effects of Lightning.—The concluding meeting of the Royal Meteorological Society for the present session was held on Wednesday evening at the Institute of Civil Engineers, Mr. Baldwin Latham, M.Inst.C.E., president, in the chair. Amongst other papers, Mr. A. J. Hands, F.R.M.S., gave an account of a curious case of damage by lightning to a church at Needwood, Staffordshire, on April 5, 1891. The church was provided with a lightning conductor, but Mr. Hands thinks that when the lightning struck the conductor a spark passed from it to some metal which was close to it, and so caused damage to the building.

Bombay Electric Lighting.—The *Indian Engineer* announces that the Bombay Corporation have decided to invite fresh tenders for electric lighting, including a clause for the continuance of such contract or the purchase of the plant at two lakhs, amending the original scheme. Owing to the present state of the municipal finances, it was also decided to draw up a representation to Government on the subject of loan and loan funds, upon which subject a long report has been prepared dealing with the question of the period over which repayment should be allowed to extend. At the suggestion of the Municipal Commissioner, the fact was embodied that the borough of Cheltenham had been allowed to borrow money for a term of 80 years.

Cable Tramways.—The South Metropolitan Tramways Company have begun the laying of the metals of their new extension from Brixton-hill to Telford-park. On this occasion, it is stated, the company will for the first time adopt the cable system of traction on an improved plan. It is understood that it is ultimately intended to carry this system the whole way from Kennington Park to the Streatham-hill terminus. We wonder if the question of electric traction has been raised in any more definite way than by sundry discussions amongst the company's own directors and engineers. When various systems—Lineff and accumulators—are being adopted, it seems rather premature to lay down a whole system of cable traction.

Aberdeen.—The question of providing the city with electric lighting has been again revived, and it is suggested that the scheme should be retained in the hands of the Corporation in place of being handed over to a private company. The original cost of the undertaking compelled the Council to drop the scheme. Since then, however, an electric engineer has furnished the Gas Committee with a report showing that by reducing the size of the buildings the cost might be reduced from £21,000 to £10,000. The plant and machinery, as originally contemplated, are left untouched. The proposals will be brought before the Town Council. It is stated that the cost of the light, which was first stated at five times that of the present rate for gas, will not be more than three times the price of gas.

London Chamber of Commerce.—A meeting of the committee of the Electrical Trade Section of the London Chamber of Commerce will be held at Botolph House, Eastcheap, on Monday, the 22nd inst., at 3 p.m., to consider the following: Letter from one of the witnesses who attended at the Board of Trade in the matter of the enquiry into electrical standards. Overhead wires: Letter as to Prof. Mengarini, of Rome, being about to transmit 2,000 h.p. from Tivoli to Rome at a pressure of 5,000 volts along bare wire. To consider the desirability of placing wires underground in future. To consider the attitude of the Electrical Section towards the proposed Crystal Palace Electrical Exhibition, and also the Taunton and South-West of England Electrical Exhibition (see enclosures). To consider whether a party from the section should visit the Frankfort Exhibition from, say, the 5th to the 15th of August.

Large Hoisting Plant.—At the Black Diamond mines, in Washington State, an electric hoisting machine has been placed at the top of a slope 450ft. in length, for the purpose of hoisting coal, the top of the slope being 3,100ft. from the mouth of the mine. The generator which supplies electricity to the motor attached to the hoist has a capacity of 120 h.p., and is located at the mouth of the mine, while the motor is capable of exerting 80 h.p. when needed. On a recent test, 12,000lb. of coal were hoisted at one trip up the slope in one and one-half minutes. The plant was manufactured and installed by the Electrical Engineering Company, of San Francisco, under the supervision of Prof. Keith, the inventor, and is pronounced a thorough success. It is claimed, says the *Electrical World*, that it makes practicable the working of many coal and other mines which could not be so cheaply and effectively worked by the usual methods of steam or pneumatic transmission of power.

The City and South London Railway.—An action has been brought in the Chancery Division, before Mr. Justice Kekewich, by the trustees of the Stockwell Orphanage, Clapham-road, against the City and South London Railway Company, for an injunction and damages, to restrain the defendant railway company from working three engines of 400 h.p. each, driving dynamos, and connected with three hydraulic engines for the purpose of working the electric railway. The case for the plaintiffs was that the vibration and noise caused by the engines and the condensed steam created such a nuisance as no statutory powers conferred on the company could possibly cover. The plaintiffs further urged that if available appliances had been used by the company the nuisance might be, if not absolutely abated, greatly mitigated. The defendant company denied negligence in the use of their engines, and affirmed that in all they had done they were acting under statutory powers. The further hearing was adjourned.

The Telephone in Sweden.—Probably, writes the Helsingfors correspondent of the *Daily News*, nowhere is the telephone brought into such general use as in Sweden. From Malmö to North Cape there is not a town or village without its exchange, and many towns, such as Gothenberg and Stockholm, are connected, allowing subscribers the free use of traffic at very moderate rates. Hitherto connections have cost about £4. 10s. each. Henceforth, however, anyone may be connected with the exchange for a fee of half a guinea once for all. The next step will be to keep an automatic register of every message, for which record a charge of 1d. will be made. There are always some 6,000 or 7,000 subscribers in Stockholm. The trouble so common in London as to "contacts" and difficulties in "ringing up" a man you want to talk to, is unknown in the Swedish capital. People have telephonic apparatus on their office desks, some have them placed beside their beds. The case is known in which a man, by means of his bedside apparatus, even ordered a five-storey house.

Institution of Civil Engineer Awards.—Amongst the list of the awards made for communications submitted during the past session to the Institution of Civil Engineers, are the following in electrical and allied branches: For papers read and discussed at the ordinary meetings—Telford medals and Telford premiums to Llewellyn Birchall Atkinson, A.K.C., and Claude William Atkinson, A.K.C., Assoc.MM.Inst.C.E., for their joint paper on "Electric Mining Machinery"; a Telford medal and a Telford premium to Rookes Evelyn Bell Crompton, M.Inst.C.E., for his paper on "The Cost of the Generation and Distribution of Electrical Energy"; a Telford premium to William Langdon for his paper on "Railway Train Lighting." For papers printed in the *Proceedings* without being discussed—A Telford premium to Bryan Donkin, jun., M.Inst.C.E., for his paper on "Thermometers in and about Steam-Cylinder Walls; with some Experiments on the Temperature of the Metal under Different Conditions." For papers read at the students' meetings—A Miller prize to Auriol Sealy-Allin, Stud.Inst.C.E., for his description of "A New Type of Water Motor."

Telephones at the Frankfort Exhibition.—A telephonic installation, connecting the Opera House with a small detached building in the grounds in the Frankfort Exhibition, has been opened. The engineers who carried out the works, Messrs. Mix and Genest, Limited, of Berlin, have provided upon the stage of the Opera House four specially-constructed transmitters—two to transmit the vocal, and two the instrumental portion of the performance. Although, owing to the peculiar staging of the piece performed on this occasion (Wagner's "Tristan and Isolde"), a most severe test was imposed, the listeners at the exhibition were delighted with the clearness and distinctness with which every note and word was reproduced. The members of the Electrotechnische Gesellschaft on their visit to the Electrical Exhibition inspected more especially the telephonic and telegraphic section. The representative of the Mix and Genest Company explained the uses and construction of the various apparatus, which are exhibited in the most complete manner by that firm. The elegant portable telephone, an exact copy of that supplied for the writing-table of the German Emperor, proved a special attraction.

Lymington.—At the meeting of the Lymington Town Council it was stated that the contract for public lighting had expired. Messrs. Crompton and Co. had addressed a letter to the committee relative to the adoption of electric lighting in the borough. The opinion of the Council was asked as to whether the matter was one that should be considered. Dr. Hill said the committee had unanimously been of opinion that the time had not arrived for the Council to consider the question of lighting the town by electricity. It would involve great expense, and such a revolution in the illumination of the town ought not to be entertained at the present time. That was the unanimous opinion of the committee; but if anyone thought otherwise, the committee would be glad to be corrected, and put in the right way. Mr. Helsby, in seconding, hoped that it would not be put off to the dim and distant future. Seeing that they were paying the sum of £300 a year for bad quality gas and very inefficient lighting—no one could deny that fact—he felt that if they could be supplied at a reasonable rate with a reliable electric light, the Council ought to be in a position to take the matter into consideration. The report was then adopted.

Students' Visit.—A number of engineers and engineering students and other gentlemen visited the British Ice Refrigerating Works and the City of London Electric Railway on Wednesday. The chief point about the ice works that may be here noted is the ingenious idea for distilling water and generating steam at the same time that is there adopted. Water is a favourite analogy for electrical engineers, and here the analogy is carried a step farther into the realms of transformer distribution. Instead of using the steam generated from the boilers for driving the engines this steam is used for making pure water for the ice, the steam for the engines being generated by the heat from the first steam. There is thus a direct transformation of energy between water and water. The visit to the electric subway was much appreciated, but we have already given sufficient details with reference to this interesting enterprise. Perhaps the most noticeable matter which arises on a second visit is the undesirable amount of noise in the tunnel. The run is extremely noisy and not particularly even. For the electric railways to be a great public success far more attention will have to be given to ensuring comfort to the ear as well as to the breathing.

Edison's Kinetograph.—Mr. Rudge, of Bristol, to whom we alluded the other week, does not seem to be the only one who has forestalled Edison's "kinetograph." Mr. Jebus Bickle, of Plymouth, writing to the *Western Morning News*, says: "Your readers will, no doubt, be interested to learn that Edison's invention is not a novel one, as provisional protection was granted to J. B. King and Jebus Bickle for a similar camera in January last. In this camera ordinary dry plates are used, and placed in the camera in 'dark slides' in the usual manner, by use of suitable mechanism, operated by clockwork on an electric motor, a series of pictures are produced about ⅜in. diameter of moving objects, in rapid succession, until the cycle motion is completed. The plates are developed in the ordinary way; positives are produced as lantern slides: when, by means of proper lenses and suitable illumination, the camera can be used as a lantern, and the objects thrown on a screen, giving the exact appearance of objects in motion. Although I do not hope to claim for this camera, which I have called the 'lorgraphoscope,' all that the great American inventor has done, yet I venture to say it will play an important part in the amusement and instruction of the rising generation."

Verona Electric Light Station.—A brief description of the Verona central station is given by Mr. Walter Meng in the *Electrotechnische Zeitschrift*, of which the following abstract is given in the *Abstracts* published by Institution of Civil Engineers: "This station has been at work since last September, and, although unimportant as regards total capacity, the author considers it interesting enough for description on account of certain details. The boilers and engines are of Italian make, the dynamos of German make. The engines are vertical compound tandem engines, developing each 85 h.p. at 265 revolutions per minute; each engine drives by belts two dynamos, which feed a three-wire network. The belt speed is 4,500ft. per minute, or considerably more than customary, but the author states that no difficulty has arisen from the high belt speed. The distributing system is overhead, and, the streets being too narrow to admit of the erection of posts, the wires are carried by iron brackets fastened to the houses at a height between the first and second floor windows. The average length of each feeder is 4,000ft., and the average current in each feeder is 350 amperes. The wires are naked, and no stouter wire than 275 mils diameter has been used, as it was found impossible to properly strain heavier wire. The total length of network is about 26,000ft., and the total length of single wire erected is 380,000ft. All junctions are made by means of fuse-boxes. The cost of the street mains amounted to 30s. per 16-c.p. lamp."

City Lighting.—The pathways along Queen Victoria-street, in the City, along by the Mansion House, King William-street, and away to the Monument, have been, or are being, laid with the underground electric light mains for the City lighting. Deep trenches are being dug by gangs of men, and filled with a score or more of iron pipes of various dimensions, and also by bitumen casing, the contractor's boards bearing the well-known name of Callender's Bitumen Company. The work seems progressing rapidly, and the asphalte paving is being replaced as the work is finished, leaving only a streak along the footpath, with junction boxes at long intervals. We have already given particulars of the Brush Company's generating station at Bankside, and we took an opportunity this week of going down to Tower-hill to see how the Thomson-Houston generating station was progressing. We were aware that they were not so advanced as the Brush Company, but the fact is there is nothing actually erected at the present moment, and the next couple of weeks is to see some quick work. The ground is on the river side, at the Wool Quay, an unoccupied piece of land next to the Custom's premises, previously used for storage purposes, of about 38,000 square feet area. The electrical plant is all on the Thomson-Houston system, and has been shipped from America. It will consist at first of two 50 arc lighters for public lighting and two 140 unit alternators for transformer distribution. The driving plant will be two 250-h.p. Babcock and Wilcox boilers, supplying steam for two 100-h.p. vertical Robey engines capable of condensing, and two 250-h.p. engines will also be erected within the next month or so. The Laing-Wharton Syndicate expect to have 25 arc lamps alight in the City by the end of this month.

Birmingham Tramways and the Telephones.—The Select Committee of the House of Lords sat on Wednesday with reference to the Bill authorising the Birmingham Tramways Company to use electric traction. The clause protecting the telephone company was the point in dispute. Sir Henry Mance, chairman of the Electric Construction Corporation, said it would cost £1,500 a mile to lay an extra conductor for the tramway, whereas the telephone company could double their wires at £5 a mile and would not need to double their whole system. Sir Joseph Kincaid, joint engineer to the tramway company, said on careful estimate one conductor would cost £1,760 per mile, and two would be £2,410 per mile. He thought the telephone service should be improved, and at the same time protected by using the double circuit. Mr. Balfour Browne, Q.C., stigmatised the action of the telephone company as an exceedingly impertinent thing, and adding expense to another company to relieve themselves of outlay, the telephone system being only on license and removable in some portions at seven days' notice. The cost to the tramway company would be £66,000, and even then the telephone wires would probably be doubled shortly. The town clerk of Birmingham gave corroborative evidence, and Mr. Pope, Q.C., addressed the committee on the same side. Mr. Fletcher Moulton, Q.C., on behalf of the telephone company, urged that that claim was moderate and just, and that there was no reason because the tramway company allowed some of their electricity to escape that the telephone company should be mulcted in £20,000 for this carelessness It was a speculative thing whether the proposed system would be adopted. There were plenty of other methods, and the tram company should be bound to refrain from injuring other businesses. The committee deliberated in private, and resolved that a clause should be inserted for the protection of the telephone company similar to the one in the West Metropolitan Act.

New Rotary Expansive Steam Engine.—Mr. A. F. G. Brown, a county gentleman, of Lwindridge Muir, Dalry, Ayrshire, has invented a new rotary engine which promises well. The engine consists of a cylinder of peculiar shape, ground to gauge in which the piston revolves keyed to a central axle. The valves are arranged to cut off at desired point and automatically close when exhaustion takes place. The engine has been made by Messrs. John Lang and Sons, of Johnstone, and tested by Prof. Jamieson, who has reported that on a series of trials of up to five consecutive hours the engine gave 29 i.h.p., and a mean of 20·78 brake h.p. at 574·5 revolutions, and an initial steam pressure in the cylinder of 80lb. The economy of steam, says the *Glasgow Herald*, is greater than any recorded results of any other rotary steam engine, and quite equal to the very best performances of Willans's famous engines of the simple single cylinder, non-condensing type, for the gross weight of feed water used per indicated horse-power hour was only 27·2lb. This consumption would have been still less had it not been for the type of boiler used, the right-angle bends in the steam-pipes, and the neglect to have these pipes properly lagged and the cylinder jacketed, for 30 per cent. of the weight of steam used passed into the cylinder as water held in suspension and from initial condensation. This is the first time, as far as we are able to learn, continues the *Herald*, that indicator diagrams have been taken from a rotary engine. Here, again, the improvements recently made by Mr. M'Innes, of Glasgow, on indicators allowed them to be obtained with a beautifully even expansion curve, and they enabled Prof. Jamieson to point out to the inventor wherein still further adaptations could be made for the benefit of the engine. The brake used at these tests was of the latest rope type, with Salter's spring balances for indicating the forward and backward stresses. It required neither oil nor blacklead throughout the five hours run at full load, although bearing upon a specially large flywheel.

Communication with Lighthouses.—Sir M. Hicks-Beach received at the Board of Trade, on Saturday, a deputation from the Associated Chamber of Commerce, which asked that a system of telegraphic or telephonic communication might be established between coast guard and lifeboat stations, lighthouses and lightships, and the general telegraphic system of the country. The President of the Board of Trade was accompanied by Sir Henry Calcraft, K.C.B., Sir George Nares, Mr. Trevor, C.B., and Mr. Walter Howell. The members of Parliament present were Sir George Elliot, Sir E. J. Reed, Sir Albert Rollit, Colonel Hill, Mr. Roe, Mr. Murdoch, Mr. Lea, Mr. Coleman, Mr. Herbert Gladstone, Mr. Isaac Wilson, Mr. Lyell, Mr. Grotrian, Mr. Esslemont, and Dr. Farquharson. Colonel Hill, M.P., presented a memorial from the Associated Chambers, which set out the need for this communication, instancing the wreck of the "Schiller," when 331 lives were lost close to the Bishop Lighthouse. The coroner's jury found that had the lighthouse keepers been able to communicate with the shore the whole of these 331 lives would have been saved. It was a matter of national importance that means of communicating with the shore should be provided, and it was estimated that this could be done for £100,000. In time of war the information that could be given of the movement of ships would be most valuable to the naval and military authorities. Other countries, such as France, Denmark, Norway, Holland, Sweden, Canada, and the Cape, had their lighthouses connected by telegraph and telephone with the general telegraphic system of those countries. Great Britain ought not to be behind any other nation in those means of saving life and property. In compliance with the suggestion of Sir Michael Hicks-Beach, they presented a list of the more important places in which communication should be established. They were: St. Agnes, Scilly, Start, St. Alban's Head, Dungeness, North Foreland, Cape Clear, Flamborough Head, Rattray Point, South Stock, St. Anne's, and Lundy Island. Other speakers having also spoke, Sir Michael Hicks-Beach, in his reply, said he did not understand that the communication was required for the purpose of trade, but for the purpose of saving life in shipwreck. He wished them to understand that he had nothing to do departmentally with the matter so far as it affected the coast guard service, which was under the Admiralty. A cable had been established four years between the "Sunk" lightship and the mainland, and the result of that was that a committee reported that, although the experiment had shown that electrical communication could be established even in such positions, yet that the experiment should be discontinued, as really having been of no service. That was the position of the case at present. The deputation wished that the experiment should not only be renewed, but that it should be very largely extended. The request that this should be done at certain places at the cost of the Mercantile Marine Fund would, he thought, come more strongly if it were backed by those who pay. Colonel Hill said he thought the shipping interest would probably not be averse to making some contribution. But there was a very strong feeling that this was not a matter entirely concerning the shipping interest; that it was of such great national importance that the Treasury might fairly be asked to undertake it. Sir Michael Hicks-Beach thereupon said he must refer them to the Chancellor of the Exchequer, though he was confident what his answer would be. All he had to dispose of was the Mercantile Marine Fund. Frankly, he was disposed to pursue the experiments somewhat further, as he did not think it enough to take the "Sunk" lightship as definitely concluding the matter, and would be perfectly willing, if the shipping interest were willing, that at any rate in some of the places mentioned, or in other places, measures should be taken for establishing electrical communication even at the expense of the Mercantile Marine Fund. He did not think that he could say anything that would show the deputation more than that he was in sympathy with them as far as he could safely go. He thought they should obtain the support also of the Chambers of Commerce, which included the shipping interests.

UNDERGROUND MAINS.—VI.

THE WESTMINSTER ELECTRIC SUPPLY CORPORATION.

Granted that concrete culverts are to be used under the pavement of the streets, and bare copper strips for the electric light mains, what is the simplest, easiest, and cheapest method of construction, allowing for the addition of more mains as wanted? This is the problem set to themselves by the Westminster Electric Supply Corporation, and a very important question for central supply companies it is. We shall see how, and in what a direct and straightforward method this question has been solved. The Westminster Company have been fortunate enough to have secured the services as chief engineer of Prof. Alexander Kennedy, Emeritus Professor of the University College of London, where his researches and lectures on mechanical engineering have made him known of the whole scientific world. That Prof. Kennedy has thought well to resign his professor's chair, and descend from theory into the arena of practical electrical engineering, is only one further sign of the influence on men and manners that the present science of electricity is exerting upon the age. Joined to scientific attainments of a high order, Prof. Kennedy has a most practical and straightforward mind, and his position, as it were, of captain of the engineering progress of a company with such a wide and wealthy field of work as that of the Westminster Company, will, we have little doubt, ensure the particulars of their installations being amongst the best thought out and arranged of all our metropolitan electric companies. Of the details of the Westminster installation we have here to treat only of the mains, but the simplicity, directness, and good result here achieved give great promise for all the future work of this corporation.

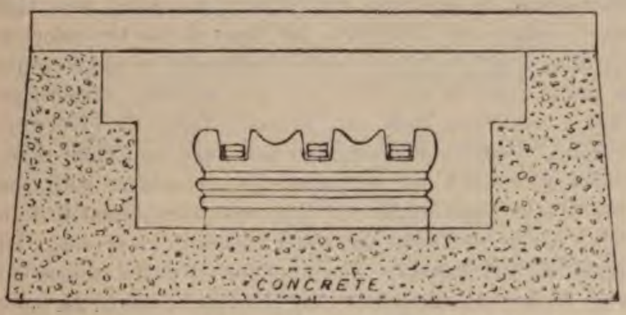


FIG. 1.—Westminster Underground Mains.

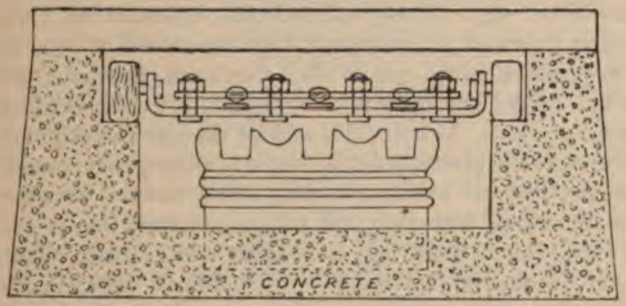


FIG. 2.—Trolley for Laying Copper Strip.

The general idea of the Westminster mains (shown in Fig. 1) is that of a small underground culvert formed of concrete, in which numerous earthenware insulators are embedded at very short intervals to carry bare copper strips. The insulators have slots to receive these copper strips, which are drawn in after construction by means of a little trolley running along inside the culvert, the copper strips simply lying upon the insulators without straining. Nothing much simpler could be devised, although the plan is evidently the final outcome of much thought, and a considerable number of trials. The system is not patented, simply being what may be termed a direct and common-sense solution of the problem. A good many miles of this culvert is already laid in conjunction with the ompany's central stations.

The Westminster system is not unlike the Crompton conduit (which has been employed in a part of the district in which Messrs. Crompton have been contractors for main laying), but the culvert devised by Prof. Kennedy is shallower, and the arrangements are all simplified by reason that the copper strips are not strained.

The usual size of the culvert for the three-wire system is 7½in. deep only, by 15in. wide. After the trench is dug the concrete is shaped by means of wood templates to the section shown, tapered slightly outwards at the bottom for strength. The culvert is made several inches wider at the top than the bottom, leaving a considerable ledge on both sides of, extending the whole length of the main as shown in the figures. This ledge serves as a kind of rail for the drawing-in trolley (see Fig. 2), which is an integral part of the Westminster system.

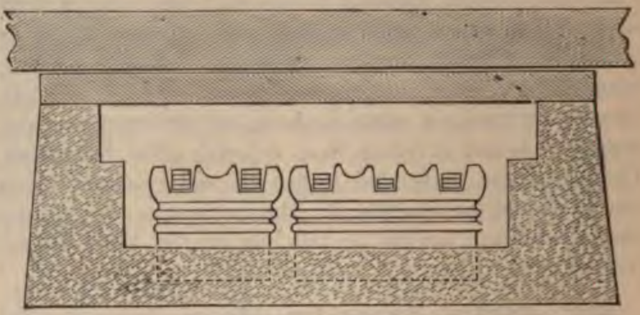
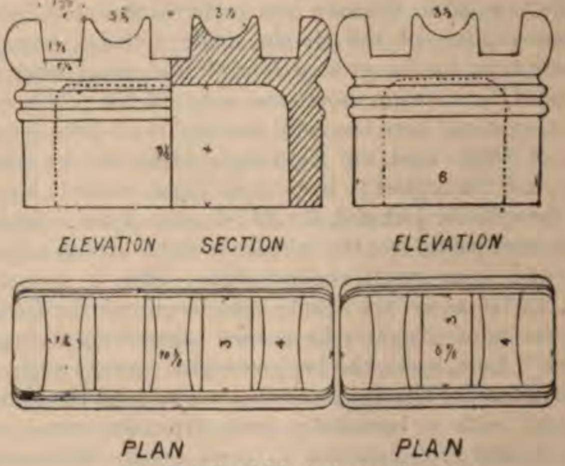


FIG. 3.—Mains and Feeders.

During the time that the concrete is still soft, hollow earthenware insulators, of the shape shown in detail in Fig. 4, are embedded in the floor of the culvert. These insulators are moulded with slots for the reception of the copper strips, and with projecting ridges to prevent the creeping of moisture. They are placed at the distance of about 6ft. apart. This distance allows the copper strip to lie in the slots with a quite negligible bending or undulation. A spacing of 8ft. was first tried, but was found slightly too much.

In all cases possible, the copper mains are laid at the time the culvert is made and before the covers are put on, as this saves the trouble of drawing in. But only sufficient copper for the immediate needs has been so laid, the remainder being afterwards added as the demand increases. The mains themselves are solid copper strips, 1in. wide by ¼in. thick—98 per cent. conductivity copper. The copper comes coiled in bundles, and a special tool has been devised by Prof. Kennedy for quickly and easily straightening it, for as the strip in this system lies without straining on the insulators, it is, of course, necessary that it should be practically without bend. The tool used is shown in detail in Fig. 5. It is a lever handle moving on a bolt which can be fixed in any suitable place; near its lower end it carries two cams, with milled edges, somewhat loosely pivoted on strong pivots. In between the jaws formed by these cams the copper strip is seized, and by a motion of the lever is forcibly stretched, straightened out, and given a slight permanent set.



4.—Details of Westminster Insulator.

The details of construction of the trolley used for drawing in all strips, except such as may be laid in place before the culvert is closed in, are fully seen in Figs. 6 and 7. A wrought-iron plate, suitably grooved and drilled with holes, and bent up to form a carriage, is mounted upon four hard wood rollers, two each side. The wrought-iron carriage has (for a three-way culvert) grooves for three strips; the strips are clamped down by a cover plate and tightly held by pointed studs. Usually only one strip is drawn in at a time. The strip to be laid is attached to the groove of the trolley corresponding to the position desired, and the rope, which has been previously passed through, is fastened to the hole in the trolley opposite the copper strip, and the whole is hauled through from the further drawing-in box, the strip simply dropping into its place as the trolley passes. The trolley has been found to act admirably.

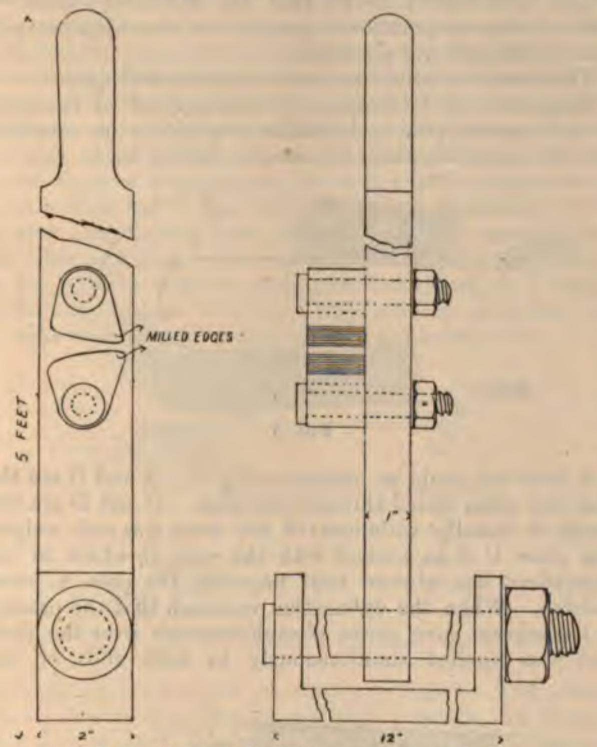
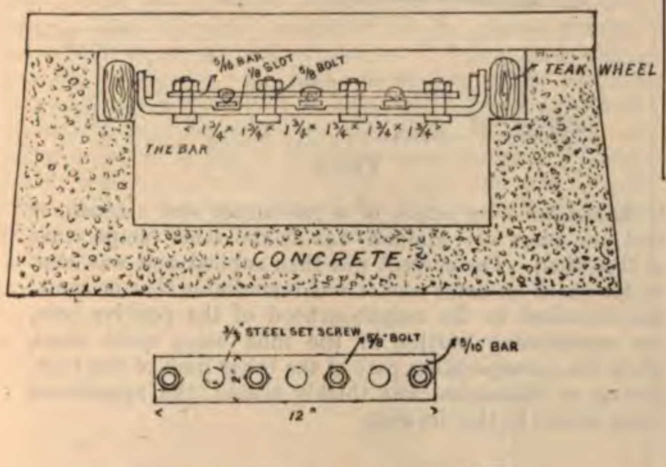
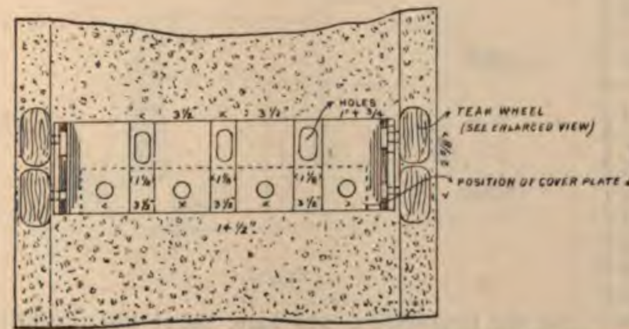


FIG. 5.—Tool for Straightening Copper Strip.





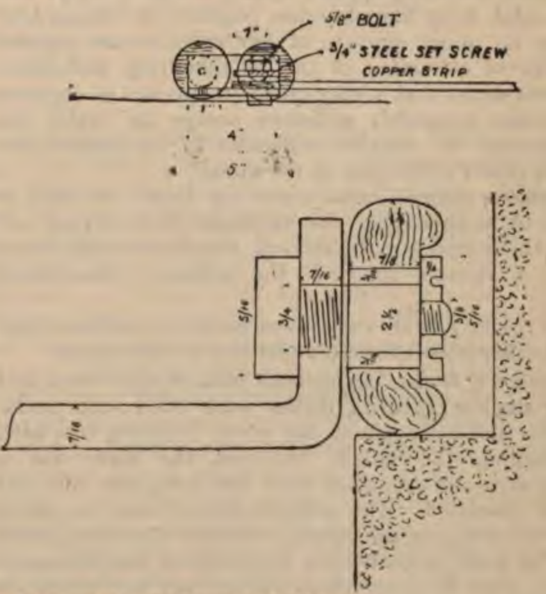


FIG. 6.—Details of Trolley for Drawing in Westminster Underground Mains.

The Westminster Company is at present supplying all its 36,000 lights on a simple two-wire system, but all arrangements are being made to change over to the three-wire system during August and September. The system actually to be used is rather a double two-wire than a three-wire system, for Prof. Kennedy has so arranged that by balancing large blocks of buildings, or sides of streets, against each other, it is seldom necessary actually to lay three lines of strip side by side in one distribution culvert.

An interesting and important point is that of insulation, and in this respect, in spite of the number of the insulator contacts, exceedingly good results are found. Even when tested on very wet days, in order to get the least favourable results possible, the result of the test of the mains themselves has been, with rare exceptions, "infinity," which in this case means that the insulation of the section tested is over 14 megohms. The large number of insulators has in no case as yet been found to have any effect in diminishing the insulation, nor has any trace been discovered of a tendency of water to form a film on the insulators, and so cause leakage. We are informed that at the time of maximum load the leakage to earth from one side of the circuit is generally *nil*, and from the other side (measured on a voltmeter) about 90 volts. The maximum leakage in current which can be got to earth under these circumstances is not generally more than will light one or sometimes two 16-c.p. lamps in parallel. This, it must be remembered, is including all house leakages and defects from 16,000 or 20,000 lamps (of 8-c.p.) in each district.

ON ELECTRICAL EVAPORATION.*

BY WILLIAM CROOKES, F.R.S.

It is well known that when a vacuum tube is furnished with internal platinum electrodes, the adjacent glass, especially near the negative pole, speedily becomes blackened, owing to the deposition of metallic platinum. The passage of the induction current greatly stimulates the motion of the residual gaseous molecules; those condensed upon and in the immediate neighbourhood of the negative pole are shot away at an immense speed in almost straight lines, the speed varying with the degree of exhaustion and with the intensity of the induced current. Platinum being used for the negative pole, not only are the gaseous molecules shot away from the electrode, but the passage of the current so affects the normal molecular motions of the metals as to remove some of the molecules from the sphere of attraction of the mass, causing them to fly off with the stream of gaseous molecules proceeding from the negative pole, and to adhere to any object near it. This property was, I believe, first pointed out by Dr.

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* Paper read before the Royal Society, June 11th, 1891.

Wright, of Yale College, and some interesting experiments are described by him in *The American Journal of Science and Arts.** The process has been much used for the production of small mirrors for physical apparatus.

This electrical volatilisation or evaporation is very similar to ordinary evaporation by the agency of heat. Cohesion in solids varies according to physical and chemical constitution; thus every kind of solid matter requires to be raised to a certain temperature before the molecules lose their fixity of position and are rendered liquid, a result which is reached at widely different temperatures. If we consider a liquid at atmospheric pressure—say, for instance, a basin of water in an open room—at molecular distances the boundary surface between the liquid and the superincumbent gas will not be a plane, but turbulent like a stormy ocean. The molecules at the surface of the liquid dart to and fro, rebound from their neighbours, and fly off in every direction. Their initial velocity may be either accelerated or retarded according to the direction of impact. The result of a collision may drive a molecule in such a direction that it remains part and parcel of the liquid; on the other hand, it may be sent upwards without any diminution of speed, and it will then be carried beyond the range of attraction of neighbouring molecules and fly off into and mingle with the superincumbent gas. If a molecule of the liquid has been driven at an angle with a velocity not sufficient to carry it beyond the range of the molecular attraction of the liquid it may still escape, since, in its excursion upwards, a gaseous molecule may strike it in the right direction, and its temporary visit may be converted into permanent residence.

The intrinsic velocity of the molecules is intensified by heat and diminished by cold. If, therefore, we raise the temperature of the water without materially increasing that of the surrounding air, the excursions of the molecules of the liquid are rendered longer and the force of impact greater, and thus the escape of molecules into the upper region of gas is increased, and we say that evaporation is augmented.

If the initial velocities of the liquid molecules can be increased by any other means than by raising the temperature, so that their escape into the gas is rendered more rapid, the result may be called "evaporation" just as well as if heat had been applied.

Hitherto I have spoken of a liquid evaporating into a gas; but the same reasoning applies equally to a solid body. But whilst a solid body like platinum requires an intense heat to enable its upper stratum of molecules to pass beyond the sphere of attraction of the neighbouring molecules, experiment shows that a very moderate amount of negative electrification superadds sufficient energy to enable the upper stratum of metallic molecules to fly beyond the attractive power of the rest of the metal.

If a gaseous medium exists above the liquid or solid, it prevents to some degree the molecules from flying off. Thus both ordinary and electrical evaporation are more rapid in a vacuum than at the ordinary atmospheric pressure.

I have recently made some experiments upon the evaporation of different substances under the electric stress.

Evaporation of Water.—A delicate balance was taken, and two very shallow porcelain dishes were filled with acidulated water and balanced on the pans. Dipping into each dish—touching the liquid, but not the dish—was a platinum wire, one connected with the induction coil and the other insulated. The balance was left free to move, but was not swinging, the pointer resting at the centre of the scale. The water in connection with the coil was first made positive. After 1¾ hours there was scarcely any difference between the weight of the insulated water and that which had been exposed to the positive current. Equilibrium being restored, the current was reversed, the negative current being kept on the dish for two hours. At the end of this time the electrified water was decidedly lighter. After having again restored equilibrium, the electrification of the dishes was reversed—*i.e.*, the one that had before been insulated was made negative, and the other one was insulated. In an hour the electrified water had become decidedly lighter than the insulated water. The experiment was performed in a room of uniform temperature, and any draught was prevented by the glass case of the balance. In a subsequent experiment in which the quantities were weighed, it was found that negatively electrified water lost in 1½ hours 1/1000th part of its weight more than did insulated water.

This experiment shows that the disturbing influence which assists evaporation is peculiar to the negative pole even at atmospheric pressures.

The metal cadmium was next experimented upon.

Evaporation of Cadmium.—If the flying off of the metal of the negative pole is similar to evaporation or volatilisation, the operation should be accelerated by heat.

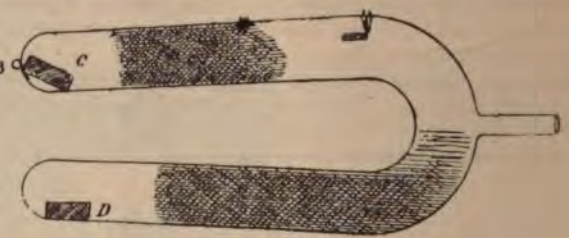

Fig. 1.

A tube was made as shown in Fig. 1. A and B are the platinum poles sealed through the glass. C and D are two blocks of metallic cadmium of the same size and weight. The piece C is in contact with the pole B, which in the experiment was always kept negative, the pole A being positive. When the exhaustion was such that the passage of the current gave green phosphorescence over the glass, heat was applied simultaneously to both ends of the U-shaped tube by means of a gas-burner and air-bath, so that one piece of cadmium was at the same temperature as the other. The current was then applied and was kept on for about an hour, and it was remarkable that no metal was deposited in the neighbourhood of the positive pole, the surrounding portion of the tube being quite clean, while the corresponding part of the other limb of the tube, having no electrodes, was thickly coated, the appearance being shown in the drawing.

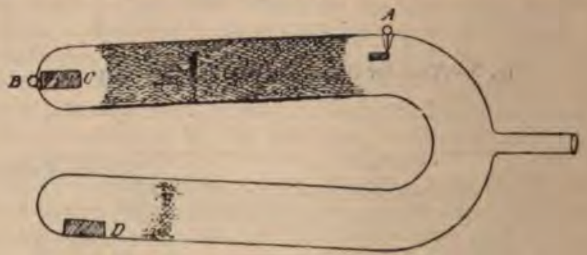

Fig. 2.

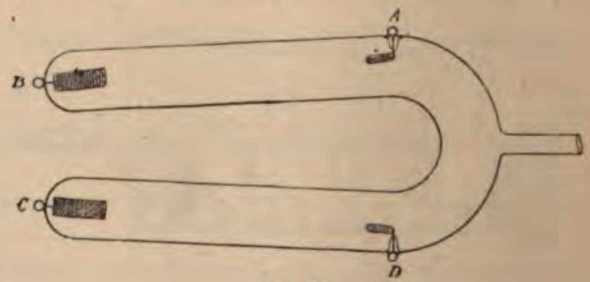

Fig. 3.

As the temperature was high, metal had distilled off from both lumps; hence there was no visible difference in the amount of the deposit in the two sides. It is evident that, to render the electrical action most visible, the temperature should be kept short of the normal volatilising point.

In the next experiment an exactly similar tube was used; the vacuum was such that the green phosphorescence of the glass was well seen, the temperature was kept just below melting point of cadmium, and the current was kept on for an hour. On examining the tube at the end of this time, the appearance was as seen in Fig. 2. A considerable deposit had taken place on the end of the tube near the negative pole, the space round the positive pole was clear, while in the limb of the tube where no electricity had been passing only a very little deposit of metal was seen, as shown in the figure.

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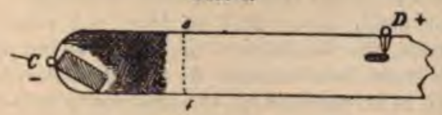
* Third Series, vol. xii., p. 49, January, 1887, and vol. xiv., p. 169, ptember, 1877.

The temperature in this experiment having been kept below the melting point, had no electricity been applied, there would have been very little, if any, evaporation. The amplitude of the molecular oscillations was increased by the rise of temperature, but not sufficiently to allow many of the molecules to pass beyond the sphere of attraction of the mass. When, however, the current was turned on, the oscillations were increased sufficiently to carry some of the molecules beyond their spheres of attraction, and hence into the vacuous space above. As in the water experiment, this only happens at the negative pole. It would seem that even after having been removed from the rest of the mass, the on-rushing stream of gaseous molecules is necessary to carry the metallic molecules away, and, as I shall presently show, even then they very quickly drop out of the ranks and deposit on the walls of the tube.

Fig. 4.



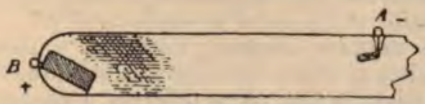


Fig. 5.

Another tube was made as shown in Fig. 3. The poles A, B, C, D were platinum wires sealed through the glass, A and D having aluminium poles covering the platinum wire. In the ends of the tube, and touching the poles B and C, were two pieces of cadmium of the same size and shape. The tube was exhausted to the phosphorescent point, and the current was turned on, C being made negative and D positive. No heat was applied. The current was kept on for about half an hour, until a good deposit of metal had been deposited on the glass, the appearance being as shown in Fig. 4, the glass near the pole C being coated with metal, while the glass round the pole D was clean. The outer boundary of the dark space during the experiment is shown by the dotted line *ef*.

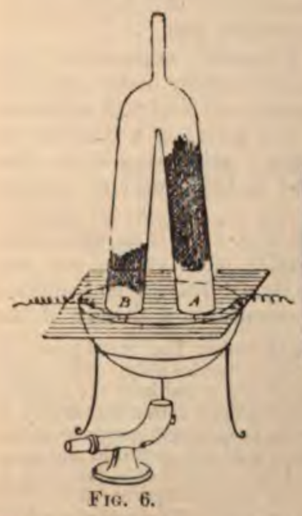


Fig. 6.

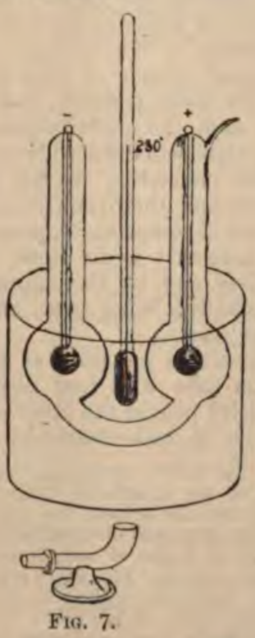


Fig. 7.

The pole B was now made positive and the pole A negative, the current being kept on for another half hour. At the end of the time the only additional effect was a slight darkening round the lump of cadmium, in the same place as, but very much fainter than, the deposit shown in Fig. 5. This is probably due to a little leakage of negative discharge from the positive pole. The experiment shows that positive electrification does not cause the metal sensibly to volatilise.

In these experiments no estimation was made of the weight of metal removed, and the cadmium only rested by its own weight upon the platinum wires that had been sealed through the glass. To render the experiment quantitative, and at the same time to remove any disturbing effect that might be caused by heating at the point of indifferent contact, the following experiments were made:

A U-shaped tube, shown in Fig. 6, had a platinum pole sealed in each end. Six grains of pure cadmium were put into each limb and fused round the platinum wire. The ends of the tube were then put into an air-bath, and kept at a temperature of 200deg. C. during the continuance of the experiment.* The exhaustion remained at 0·00076 mm., or 1 M. The induction current was kept going for 35 minutes, the pole A being negative and B positive. At the end of this time it was seen that most of the cadmium had disappeared from the negative pole, leaving the platinum wire clean, no metal being deposited near it, and the molecules appearing to have been shot off to a distance of about ¾in. The appearance of the positive pole was very different; scarcely any of the cadmium had been volatilised, and the condensed metal came almost close to the pole. The tube was opened, and the remaining wires and metal were weighed. The cadmium was then dissolved off the poles in dilute acid; the residue was washed, dried, and weighed.

	Positive pole.		Negative pole.
Original weight of cadmium.........	6·00 grains.	...	6·00 grains.
Cadmium remaining on the pole ...	3·65 ,,	...	0·25 ,,
Cadmium volatilised in 35 minutes	2·35 ,,	...	5·75 ,,

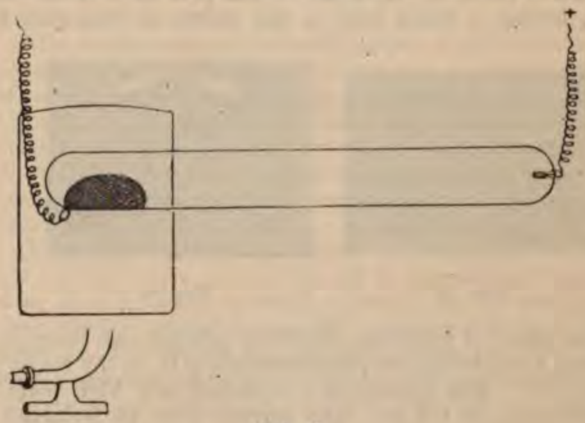


Fig. 8.

The difference between the cadmium driven from the two poles having proved to be so decided, another experiment was tried in a tube so arranged that the metal could be more easily weighed before and after the experiment. The apparatus is shown in Fig. 7. A tube was blown U-shaped, having a bulb in each limb. The platinum poles were, as before, at the extremities of each limb, and in each bulb was suspended from a small platinum hook a small lump of cadmium, the metal having been cast on to the wire. The wires were each weighed with and without the cadmium. The tube was exhausted, and the lower half of the tube was enclosed in a metal pot containing paraffin wax, the temperature being kept at 230deg. C. during the continuance of the experiment. A deposit around the negative pole took place almost immediately, and in five minutes the bulb surrounding it was opaque with deposited metal. The positive pole with its surrounding luminosity could be easily seen the whole time. In 30 minutes the experiment was stopped, and after all was cold the tube was opened and the wires weighed again. The results were as follows:

	Positive pole.		Negative pole.
Original weight of cadmium	9·34 grains.	...	9·38 grains.
Weight after experiment	9·25 ,,	...	1·86 ,,
Cadmium volatilised in 30 minutes	0·09 ,,	...	7·52 ,,

Finding that cadmium volatilised so readily under the action of the induction current, a large quantity, about 350 grains, of the pure metal, was sealed up in a tube arranged as in Fig. 8, and the end of the tube containing the metal was heated to a little above the melting point; the molten metal being made the negative pole, in a few hours the whole quantity had volatilised and condensed in a thick layer on the far end of the tube, near, but not touching, the positive pole.

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* Cadmium melts at 320deg. and boils at 860deg.

Volatilisation of Silver.—Silver was the next metal experimented upon. The apparatus was similar to that used for the cadmium experiments, Fig. 7. Small lumps of pure silver were cast on the ends of platinum wires, and suspended to the inner ends of platinum terminals passing through the glass bulb. The platinum wires were protected by glass, so that only the silver balls were exposed. The whole apparatus was enclosed in a metal box lined with mica, and the temperature was kept as high as the glass would allow without softening. The apparatus was exhausted to a dark space of 3 mm., and the current was kept on for 1½ hours. The weights of silver, before and after the experiment, were as follows:

	Positive pole.		Negative pole.
Original weight of silver............	18·14 grains	..	24·63 grains.
Weight after the experiment......	18·13 ,,	...	24·44 ,,
Silver volatilised in 1½ hours......	0·01 ,,	...	0·19 ,,

It having been found that silver volatilised readily from the negative pole in a good vacuum, experiments were instituted to ascertain whether the molecules of metal shot off from the pole were instrumental in producing phosphorescence. A glass apparatus was made, as shown in Fig. 9. A pear-shaped bulb of German glass has, near the small end, an inner concave negative pole, A, of pure silver, so mounted that its inverted image is thrown upon the opposite end of the tube. In front of the pole is a screen of mica, having a small hole in the centre, so that only a narrow pencil of rays from the silver pole can pass through, forming a bright spot of phosphorescence, D, at the far end of the bulb. The exhaustion was pushed to a high point, 0·00068 mm., or 0·9 M. The current from an induction coil was allowed to pass continuously for some hours, the silver pole being kept negative so as to drive off a certain portion of the silver electrode. On subsequent examination it was found that the silver had all been deposited in the immediate neighbourhood of the pole, whilst at the far end of the tube the spot D, that had been continuously glowing with phosphorescent light, was practically free from silver.

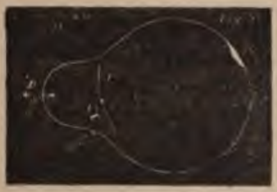

FIG. 9.

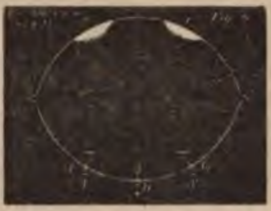

FIG. 10.

A tube was next made as shown in Fig. 10. It had two negative poles connected together, A A′, so placed as to project two luminous spots on the phosphorescent glass of the tube. One of the electrodes, A′, was of silver, a volatile metal; the other, A, was of aluminium, practically non-volatile. On connecting the two negative poles, A A′, with one terminal of the coil, and the positive pole, B, with the other terminal, it was seen in the course of half an hour that a considerable quantity of metal had been projected from the silver negative pole, blackening the tube in its neighbourhood, while no projection of metallic particles took place from the aluminium positive pole. During the whole time of the experiment, however, the two patches of phosphorescent light, C and C′, had been glowing with exactly the same intensity, showing that the active agent in effecting phosphorescence was not the molecules of the solid projected from the poles, but the residual gaseous particles, or "radiant matter."

In the tubes hitherto made containing silver, it had not been easy to observe the spectrum of the negative pole, owing to the rapid manner in which the deposit obscured the glass. A special tube, Fig. 11, was therefore devised of the llowing character. The silver pole, A, was attached to the platinum pole at one end of the tube, and the aluminium positive pole, B, was at the side. The end of the tube opposite the silver pole was rounded, and the spectroscope was arranged to observe the light of the volatilising silver "end on," as shown in the figure. In this way the deposit of silver offered no obstruction to the light, as none was deposited except on the sides of the tube surrounding the silver. At a vacuum giving a dark space of about 3 mm. from the silver, a greenish-white glow was seen to surround the metal. This glow gave a very brilliant spectrum. The spark from silver poles in air was brought into the same field of view as the vacuum glow, by means of a right-angled prism attached to the spectroscope, and the two spectra were compared. The two strong green lines of silver were visible in each spectrum; the measurements taken of their wave-lengths were 3,344 and 3,675, numbers which are so close to Thalén's numbers as to leave no doubt that they are the silver lines. At a pressure giving a dark space of 2 mm. the spectrum was very bright, and consisted chiefly of the two green lines and the red and green hydrogen lines. The intercalation of a Leyden jar into the circuit does not materially increase the brilliancy of the lines, but it brings out the well-known air lines. At this pressure not much silver flies off from the pole. At a higher vacuum, the luminosity round the silver pole gets less and the green lines vanish. At an exhaustion of about one-millionth of an atmosphere the luminosity is feeble, the silver pole has exactly the appearance of being red hot, and the volatilisation of the metal proceeds rapidly.*

If, for the negative electrode, instead of a pure metal such as cadmium or silver, an alloy was used, the different components might be shot off to different distances, and in this way make an electrical separation, a sort of fractional distillation. A negative terminal was formed of clean brass, and submitted to the electrical discharge *in vacuo*; the deposit obtained was of the colour of brass throughout, and on treating the deposit chemically I could detect no separation of its component metals, copper and zinc.

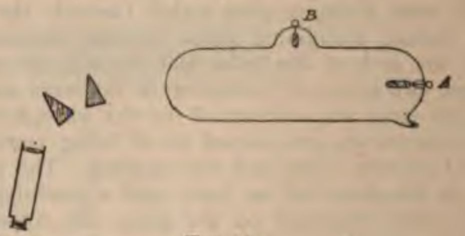

FIG. 11.

Returning to the analogy of liquid evaporation, if we take several liquids of different boiling points, put them under the same pressure, and apply the same amount of heat to each, the quantity passing from the liquid to the gaseous state will differ widely in each case.

It was interesting to try a parallel experiment with metals, to find their comparative volatility under the same conditions of temperature, pressure, and electrical influence. It was necessary to fix upon one metal as a standard of comparison, and for this purpose I selected gold, its electrical volatility being great, and it being easy to prepare in a pure state.

An apparatus was made as in Fig. 12. It is practically a vacuum tube with four negative poles at one end and one positive pole at the other. By a revolving commutator I was able to make electrical connection with each of the four negative poles in succession for exactly the same length of time (about six seconds); by this means the variations in the strength of the current, the experiment lasting some hours, affected each metal alike.

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* Like the action producing volatilisation, the "red heat" is confined to the superficial layers of molecules only. The metal instantly assumes, or loses, the appearance of red heat the moment the current is turned on or off, showing that, if the appearance is really due to a rise of temperature, it does not penetrate much below the surface. The extra activity of the metallic molecules necessary to volatilise them is, in these experiments, confined to the surface only, or the whole mass would evaporate at once, as when a metallic wire is deflagrated by the discharge of a powerful Leyden jar. When this extra activity is produced by artificial heat one of the effects is the emission of red light; so it is not unreasonable to imagine that when the extra activity is produced by electricity the emission of red light should also accompany the separation of molecules from the mass. In comparison with electricity heat is a wasteful agent for promoting volatilisation, as the whole mass must be raised to the requisite temperature to produce a surface action merely; whereas the action of electrification does not appear to penetrate much below the surface.

The exposed surface of the various metals used as negative poles was kept uniform by taking them in the form of wires that had all been drawn through the same standard hole in the draw-plate, and cutting them by gauge to a uniform length. The actual size used was 0·8 mm. in diameter, and 20 mm. long.

The comparison metal gold had to be used in each experiment. The apparatus thus enabled me to compare three different metals each time. The length of time that the current was kept on the revolving commutator in each experiment was eight hours, making two hours of electrification for each of the four negative electrodes. The pressure was such as to give a dark space of 6 mm.

The fusible metals—tin, cadmium, and lead—when put into the apparatus in the form of wires, very quickly melted. To avoid this difficulty a special form of pole was devised. Some small circular porcelain basins were made, 9 mm. diameter; through a small hole in the bottom a short length of iron wire, 0·8 mm. in diameter, was passed, projecting downwards about 5 mm.; the basin was then filled to the brim with the metal to be tested, and was fitted into the apparatus exactly in the same way as the wires; the internal diameter of the basins at the brim was 7 mm., and the negative metal filed flat was thus formed of a circular disc 7 mm. diameter. The standard gold pole being treated in the same way, the numbers obtained for the fusible metals can be compared with gold, and take their place in the table.

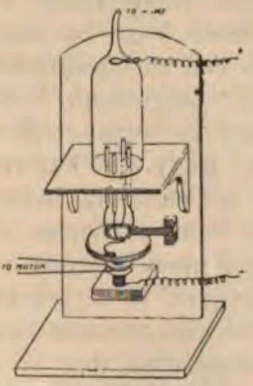

FIG. 12.

The following table of the comparative volatilities was in this way obtained, taking gold as = 100:

Palladium	108·00	Platinum	44·00
Gold	100·00	Copper	40·24
Silver	82·68	Cadmium	31·99
Lead	75·04	Nickel	10·99
Tin	56·96	Iridium	10·49
Brass	51·58	Iron	5·50

In this experiment equal surfaces of each metal were exposed to the current. By dividing the numbers so obtained by the specific gravity of the metal, the following order is found:

Palladium	9·00	Copper	2·52
Silver	7·88	Platinum	2·02
Tin	7·76	Nickel	1·29
Lead	6·61	Iron	0·71
Gold	5·18	Iridium	0·47
Cadmium	3·72		

Aluminium and magnesium appear to be practically non-volatile under these circumstances.

The order of metals in the table shows at once that the electrical volatility in the solid state does not correspond with the order of melting points, of atomic weights, or of any other well-known constant. The experiment with some of the typical metals was repeated, and the numbers obtained did not vary materially from those given above, showing that the order is not likely to be far wrong.

It is seen in the above table that the electrical volatility of silver is high, while that of cadmium is low. In the two earlier experiments, where cadmium and silver were taken, the cadmium negative electrode in 30 minutes lost 7·52 grains, whilst the silver negative electrode in 1½ hours only lost 0·19 grains. This apparent discrepancy is easily explained by the fact (already noted in the case of cadmium) that the maximum evaporation effect, due to electrical disturbance, takes place when the metal is at or near the point of liquefaction. If it were possible to form a negative pole *in vacuo* of molten silver, then the quantity volatilised in a given time would be probably much more than that of cadmium.

Gold having proved to be readily volatile under the electric current, an experiment was tried with a view to producing a larger quantity of the volatilised metal. A tube was made having at one end a negative pole composed of a weighed brush of fine wires of pure gold, and an aluminium pole at the other end.

The tube was exhausted and the current from the induction coil put on, making the gold brush negative; the resistance of the tube was found to increase considerably as the walls became coated with metal, so much so that, to enable the current to pass through, air had to be let in after a while, depressing the gauge ½ mm.

The weight of the brush before experiment was 35·4940 grains. The induction current was kept on the tube for 14½ hours; at the end of this time the tube was opened and the brush removed. It now weighed 32·5613, showing a loss of 2·9327 grains. When heated below redness the deposited film of gold was easily removed from the walls of the tube in the form of very brilliant foil.

After having been subjected to electrical volatilisation, the appearance of the residual piece of gold under the microscope, using a ¼in. object-glass, was very like that of electrolytically deposited metal, pitted all over with minute hollows.

This experiment on the volatilisation of gold having produced good coherent films of that metal, a similar experiment was tried, using a brush of platinum as a negative electrode. On referring to the table it will be seen that the electrical volatility of platinum is much lower than that of gold, but it was thought that by taking longer time a sufficient quantity might be volatilised to enable it to be removed from the tube.

The vacuum tube was exhausted to such a point as to give a dark space of 6 mm., and it was found, as in the case of gold, that as a coating of metal was deposited upon the glass the resistance rapidly increased, but in a much more marked degree, the residual gas in the tube apparently becoming absorbed as the deposition proceeded. It was necessary to let a little air into the tube about every 30 minutes, to reduce the vacuum. This appears to show that the platinum was being deposited in a porous spongy form, with great power of occluding the residual gas.

Heating the tube when it had become in this way non-conducting liberated sufficient gas to depress the gauge of the pump 1 mm., and to reduce the vacuum so as to give a dark space of about 3 mm. This gas was not reabsorbed on cooling, but on passing the current for 10 minutes the tube again refused to conduct, owing to absorption. The tube was again heated, with another liberation of gas, but much less than before, and this time the whole was reabsorbed on cooling.

The current was kept on this tube for 25 hours; it was then opened, but I could not remove the deposited metal except in small pieces, as it was brittle and porous. Weighing the brush that had formed the negative pole gave the following results:

	Grains.
Weight of platinum before experiment	10·1940
,, ,, after experiment	8·1570
Loss by volatilisation in 25 hours	2·0370

Another experiment was made similar to that with gold and platinum, but using silver as the negative pole, the pure metal being formed into a brush of fine wires. Less gas was occluded during the progress of this experiment than in the case of platinum. The silver behaved the same as gold, the metal deposited freely, and the vacuum was easily kept at a dark space of 6 mm. by the very occasional admission of a trace of air. In 20 hours nearly three grains of silver were volatilised. The deposit of silver was detached without difficulty from the glass in the form of brilliant foil.

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

GLASGOW.

In our last issue we gave the discussion in the Council upon the suggestions of the sub-committee on electric lighting; in this issue we give the text of the reports made by the experts to the sub-committee. It will be seen that Mr. R. E. Crompton was instructed to "prepare a scheme for lighting by electricity the compulsory area" in the central part of the city, and it was resolved to adopt the report of the sub-committee by 30 votes to 7; which resolution practically involves an expenditure of over £51,000 upon the lines of Mr. Crompton's scheme. Any scheme submitted would of course be subjected to violent, if not virulent, opposition; because at the present time practice is tending in two directions. Each direction has its hot partisans, who are perfectly certain their views are correct, and emphatically certain their opponents' views are wrong. On the one hand, then, we have advocates of high pressure; on the other hand, we have advocates of low pressure—there being a few men who believe that much may be said on both sides. The Americans call the moderates by the euphonious name of "mugwumps"—as sitting on the fence preparatory to slipping off on the same side as the winning party. Whatever name may be given to them we certainly favour the moderates, believing that each particular case as it arises should be decided upon its merits. Mr. Crompton's scheme for Glasgow is a low-pressure one, and supporters of the high-pressure system have hardly been fair in suggesting that he is so enamoured of this system as to be unable to fully understand the advantages of the other system. We should have supposed that all the large contractors were more fully conversant with the advantages of both systems than any outsider could be. They have to be prepared to supply plant for either system, although their own predilection may favour one more than the other. In the case of Glasgow, however, opponents who at first spoke strongly against the scheme, are acknowledging that there is something in it which at first they did not understand. Fuller explanations have enlightened them. What a pity it is that some of these men did not seek enlightenment first. The report—which, with the exception of the key plan, we give in full—will give all of us an opportunity of deciding how near or how far Mr. Crompton is to the facts of practice. He has estimated certain "costs." Will his estimates be proved correct when the plant is running? The answer time alone can give, but the profession have in these figures what they have never had so carefully and so publicly before—the data from which to start in order to know the exact position of electrical engineering at the present day. No one expects an architect's or an engineer's figures to be more than approximately correct, but we all want to ascertain if the estimates of the electrical engineer are ab as correct as those of his brethren in other branches of engineering work. We believe that to the energy and local knowledge of Mr. Foulis is due the greater part of the information from which Mr. Crompton has prepared his scheme and the estimates given therewith.

COMMUNICATION TO LIGHTSHIPS.

The very necessary extension of electrical communication to lighthouses and coast guard stations has advanced another small step this week, by the reception of an influential deputation by the President of the Board of Trade. Sir Michael Hicks-Beach, while avowing his disposition to advance the matter, pointed out that the question was one to be referred to the Chancellor of the Exchequer. He had, however, control of the Mercantile Marine Fund, with which, he said, he was willing to assist experiments, if the shipping interests themselves also contributed. The *Western Daily Mercury* is very caustic upon the question:

"The enormous difficulty," it says, "of moving the Government departments to take any step in the direction of practical reform is well illustrated by the delays which have occurred in the matter of organising a system of electric communication between lighthouses and the shore. The advantages of such a system are so obvious that it ought not to need ten minutes' argument to convince the most obtuse and unwilling listener. Yet the Chamber of Commerce—Plymouth taking a leading part—have been hammering away at this thing for years, and still nothing is done. The question was again brought to the attention of the Board of Trade by a deputation from the Associated Chambers of Commerce, which may be taken as representing the commercial opinion of the Three Kingdoms. What they wish to see accomplished would, at a cost of not more than £100,000, effect an immense saving of life and property on our coasts. It is more than probable that the entire outlay would be recouped in the course of two or three years by the salvation of ships and cargoes, to say nothing of precious lives. And yet red tapeism and circumlocution are so all-powerful that as yet no way has been devised for doing what is so urgently required. The thing is tossed about 'from pillar to post,' from Board of Trade to Treasury, Admiralty, and Trinity Brethren; and between them all, year after year is wasted until those who are trying to overcome the inertia of officialdom, are almost tempted to give up the task in despair."

It has been very generally thought that nothing would be more easy than for the Post Office, out of its surplus millions, to supply the £100,000 that is needed, and extend its system of telegraphic communication to the lighthouses. But it must be remembered that the Post Office is in reality a business undertaking, applying its resources for commercial purposes, and has no direct authority to expend large sums of money on even such a desirable object as saving life and property. The matter is a national question, and what is needed is authority for the expenditure for this sum for the definite national purpose. A short Act of Parliament, voting a specific sum for the specific purpose, would be the proper way out of the difficulty, and while obtaining all the aid it can from the shipping interests, to direct their energies to obtaining this would be the proper course for the Associated Chambers of Commerce to pursue.

FARADAY CENTENARY.

The Royal Institution, wherein Faraday made most of the discoveries which have rendered his name famous in the annals of science, has arranged for two lectures in honour of the centenary of the birth of the illustrious professor. The first of these lectures was delivered by Lord Rayleigh on Wednesday to a distinguished audience, presided over by the Prince of Wales. It is not very difficult to indicate the position in which Faraday stood in the ranks of discoverers in the nineteenth century. We doubt if there would be a dissentient voice in any civilised community against placing him first. While chemical science has advanced by leaps and bounds, especially in that department termed organic, the discoveries therein have not taken hold of the mind of the world like the discoveries in electricity. Faraday was the worker who made it possible to apply electricity to the wants of everyday life. To him we owe the germ of all the applications to light and power which are now such prominent features of industrial progress. Lord Rayleigh pointed out that Faraday's experiments—which would tax the patience of many to perform now, or to see performed—led to fundamental discoveries which have become familiar to all serious students of physics. He desired his audience to remember that the methods open to Faraday, and the apparatus to his hand, were widely different to those at our command to-day. Faraday, in fact, created methods, and his discoveries led to the design of new apparatus. At the time of the discovery of the reaction between magnetism and electricity, Lord Rayleigh says Faraday wrote to his friend, R. Phillips: "I am busy just now again on electromagnetism, and think I have got hold of a good thing, but can't say. It may be a weed, instead of a fish, that, after all my labour, I may at last pull up." Every student knows that the discovery was the first alternate-current machine. In calling attention to Faraday's work there is little that is new to be said, but it is useful periodically to point out how careful he was to ensure the correctness of his deductions, and how completely his life was wrapt up in investigating Nature's secrets. The second lecture will be delivered by Prof. Dewar next week.

CITY AND SOUTH LONDON.

Our readers will have noticed that for some time past we have given the weekly earnings of this line. From the figures thus given, which, of course, are supplied by the company, we find that the receipts for the past 13 weeks are just over £10,000. If this average is continued, it gives the £40,000 income mentioned by the chairman at the extraordinary general meeting held on Tuesday. While, however, it is possible to check the income, it is not so easy to check the expenditure. This income of £40,000 is *estimated* to realise a profit of £12,000, but it will be perceived that the profit is an estimate only. The public, or the shareholding public asked to provide further capital, should be supplied with fuller information. It may be assumed that with a regular and comfortable service the number of passengers will gradually increase, and also the income. There requires to be, however, a very large increase of profit before a fair dividend is paid to the shareholders, and this profit will be obtained only upon the supposition that the profit increases in much greater ratio after a certain income is obtained up to the point of full capacity of plant.

CORRESPONDENCE.

FIRE.

SIR,—The electrical department, including drawing-office and testing-room, of Messrs. Barnett, Wynne, and Barnard, electrical engineers, Newcastle-on-Tyne, was entirely destroyed by fire on Saturday afternoon last.

All drawings, and many electrical instruments, stored there prior to being removed to their new works, now building at Walker-on-Tyne, were destroyed, and great inconvenience is temporarily experienced.—Yours, etc.,

BARNETT, WYNNE, AND BARNARD.

92, Quayside, Newcastle-on-Tyne, June 16, 1891.

THE USE OF MATHEMATICS.

BY SYDNEY F. WALKER.

Probably there is no more serious bone of contention between the men whose lot it is to carry out work, especially in connection with electrical engineering, and those who think out the principles upon which that work must be arranged if it is to be successful, than the use of mathematics. Practical men have an incipient distrust of long expressions, and they are apt to shirk reading the able papers of our eminent scientists when they espy the square root symbol covering expressions of many terms, or the equally ominous $\frac{d\,x}{d\,y}$. And, with every respect for the invaluable work which has been done by mathematicians, the practical engineer's distrust is not altogether misplaced. In almost every mathematical expression that is used in the papers before referred to, there lurks an innocent-looking term or factor written sometimes α, sometimes β, and sometimes as some other letter. The innocent nearly always represents what is playfully termed "*a constant*," and the whole bearing of the expression, however complicated, or however simple, turns upon whether the value of this arbitrary *constant* is correct. The general reader and the practical engineer are rarely permitted to see how the value of the *constant* has been arrived at. Further, though the men who wield these awful creations with such ease are looked up to with the greatest deference by the practical engineer, there is always a lurking doubt in his mind whether the eminent ones may not possibly have lost their way in the haze of figures and symbols that they have created. There is a very old story told of how a man who was not a highly-trained mathematician, obtained the reputation of being one. He was walking with a friend to whom mathematics, the very highest and deepest, were as A B C, and his friend was detailing to him the particulars of an intricate problem that he had just solved. The non-mathematician, it need hardly be said, did not follow his friend's argument, but there came a point in the narration of the problem when some response was needed.

"And thus, you see, we have x," said the mathemat. "Humph!" said his friend, "have we?" really not caring a straw, and not knowing what on earth was meant by having got hold of x. The interrogation, however, set the mathemat thinking. "Let me see, have we got x after all? No; to be sure, you are right. So and so; we have not got x," and thereupon he went over the whole ground again, having discovered that he had made a trifling error in the earlier part of the solution, and crediting his friend with having detected it. Most of us remember, too, what trouble has been caused us when making algebraical calculations, by that error we so often made of putting down the wrong sign between two terms of an expression, and we cannot therefore help feeling that possibly a wrong sign may be hidden in the middle of one of those elaborate calculations, and that in consequence the practical work we are designing upon it may turn out all wrong.

On the other hand, those of us who think at all have a feeling that a mathematical training is of immense service to a youngster who is going in for any branch of engineering. Yet we should often be extremely puzzled to give a man of the old rule-of-thumb type a really satisfactory reason for our faith. We have often been told, usually by outsiders it is true, to confine our calculations to the space occupied by a postage stamp, and it is also true that no very deep study of mathematics is necessary for the proper appreciation and use of Ohm's law, it is often therefore not at all easy to convince the father of a would-be electrical engineer that he should keep his son at school or college long enough to acquire a knowledge of the higher mathematics. When, therefore, an opportunity does occur of pointing the moral by an actual example, an apology will hardly be needed for bringing it forward.

The above reasoning occurred to the writer when listening to Mr. Swinburne's paper on "Transformer Distribution," at the Institution of Electrical Engineers, and the following example of the living use of an acquaintance with mathematics was furnished. In the course of his paper, Mr. Swinburne proceeded to trace the difference in the behaviour of large and small alternators when running in parallel, with reference to the effect of the reaction of the armature upon the field and the lagging current, and brought out the fact, as stated by him, that taking the current in the armature in two quantities—viz., that which lags and that which does not—the power wasted in the armature depends upon the resistance of its coils multiplied by the sum of the squares of the two currents, not on the resistance multiplied by the square of their sum; or as $r\,(C^2 + c^2)$, not as $r\,(C + c)^2$. To an outsider the above would look like a mere play upon words, and even to men accustomed to the use of figures, its full significance is by no means apparent at first sight, but on expanding the expression $(C + c)^2$ into its form $C^2 + 2\,C\,c + c^2$, the difference between the two is seen at once. It consists of twice the product of the two currents, which may under certain conditions amount to a considerable figure.

Other cases of this kind may no doubt frequently be met with if one is only on the lookout for them.

To those, also, who have thought about the matter, many instances will occur not readily translatable into living cases, where a mathematical training is of immense service. What tends more than the study of Euclid to produce the calm judicial mind that is necessary not only for the pure scientist, but for the engineer, and, perhaps, above all, for the man of business?

Or, again, how much easier it is to appreciate and to provide for the bearing that the independent actions of various parts of an apparatus have on each other, and of the bearing that various independent units in a business have on each other, after a mathematical training; though possibly neither into the engineer's mind, nor into that of the business man, does the thought of a mathematical expression enter. Daily, hourly, those of us who are engaged in engineering of every branc electrical engineering, use mathematics that we learnt years ago, though we may not be able even to write down the expression of the formula we are using.

JENNINGS AND BREWER'S RESERVOIR LEVEL INDICATOR.

The utility of apparatus which indicates in an engine-room or office the height of water in a distant reservoir is so obvious, that it is surprising that more attention has not been given to the subject. Practically the only agency which can be utilised to effect this purpose is that of electricity, and years ago the idea of so employing it was taken up by electrical instrument makers. As a matter of fact, the problem to be solved has more of the mechanical than the electrical about it, and so we find one of the latest and best of these level indicators brought out by patentees who have endeavoured to correct certain faults of a mechanical nature which existed in the older forms.

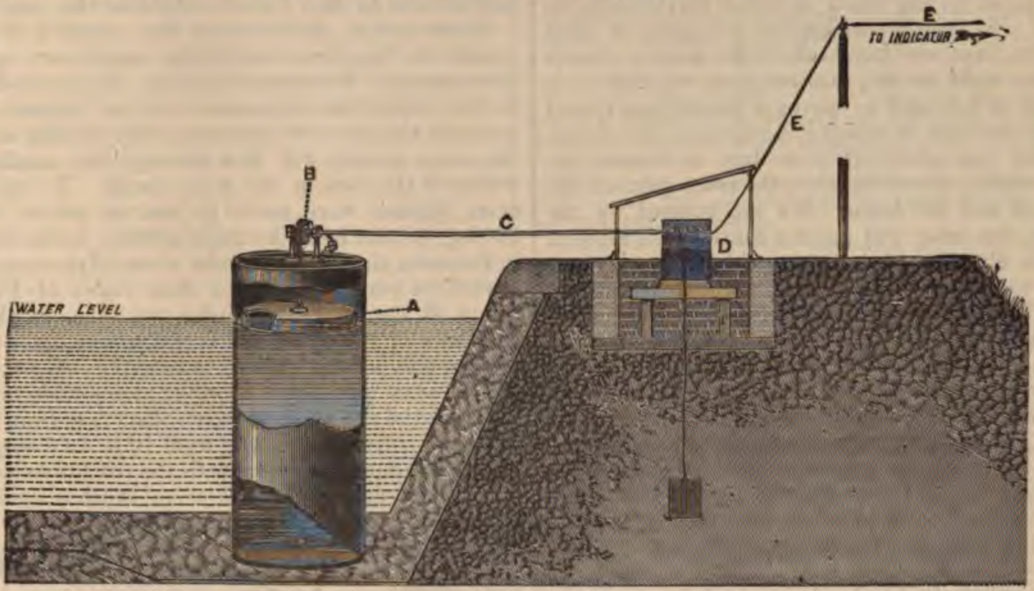

FIG. 1.—Jennings and Brewer's Level Indicator, showing Float, Transmitter, and Line Wire.

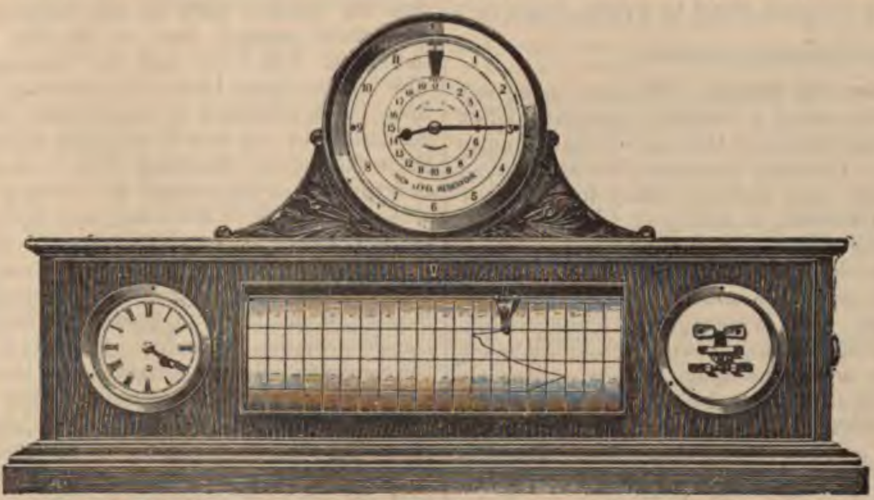

FIG. 2.—Jennings and Brewer's Level Indicator. External View of Receiver.

Messrs. Jennings and Brewer's apparatus consists of a cylinder sunk in the reservoir (*vide* Fig. 1), inside which is a float, A, attached to a chain passing over a pulley, B, and counterpoised by a weight. The pulley is keyed to a shaft, C, which actuates the mechanism in the transmitter, D. For every inch, or other predetermined height, of rise or fall in the water level, a current is sent from the transmitter to the receiver and recorder, Fig. 2, and is there indicated on a dial and registered (if required) on a diagram. The transmitter is very ingeniously constructed. Although the shaft, C, revolves either backwards or forwards, as the float may be rising or falling, the transmitting mechanism which completes the circuit and sends a current through the line always runs in the same direction. The means taken to indicate rise or fall on the receiver is an electrical commutator in the transmitter, which is actuated by a double roller cam, and which, in the old telegraph parlance, sends either a copper or zinc current to line when the circuit has been completed, which is effected by another portion of the apparatus. Thus, suppose the float is rising a copper current will be sent, and if falling a zinc. Contact is only made for a second or two, just sufficient to secure efficient working, so that the battery is worked most economically. In other words, the circuit is an open one, and the battery is only worked during the second or two when contact is made. For a line of four to five miles a battery of four to five No. 2 Leclanché cells is sufficient. As will be seen from the illustration, a single wire is used for the line, the transmitter and receiver being respectively connected to earth.

The "receiver" is shown in Fig. 2. The current enters at the right, traverses the relay there shown, energises one or other of the electromagnet cores at the top, according to the direction of the current, pulls over the tongue in the centre, which then makes contact with one or other of the lower contacts. These are connected with a local battery of from seven to eight Leclanché's, the current from which energises another set of electromagnets fixed behind the dial marked "High-Level Reservoir." An armature connected with a train of wheels is so pivoted as to be under the influence of these electromagnets, and is attracted by them one way or the other according to the nature of the current transmitted. If the current is copper, the motion of the train of wheels will be continuous in the direction of rise, and the dial hands will indicate the amount in inches (large hand) and feet (small hand). The same gearing also actuates a wedge-shaped disc at the top of the dial. When water is rising this disc shows white, when falling, red; so that an engine driver can tell at a glance how matters are going. The recorder portion of the apparatus is shown below the dial in the centre, the drum on which the diagram is pasted being driven by the clock at the left-hand side, which is also useful as a time indicator. The pen, a special non-corrosive one, is fitted to an attachment, which is driven by delicate chain gearing worked by a toothed wheel gearing with the train which moves the dial hands. The paper on the drum is ruled horizontally to indicate hours. At each predetermined variation of level (an inch in the case we have taken) the pen is drawn slightly to the right or left, according to whether it is recording a rise or fall, and so leaves a permanent record of the fact and the time at which it occurred. The drum, clock, and relay are protected from dust as shown, but everything is readily accessible when the front part of the case is unlocked and let down. We are assured by the patentees that the relay will stand a considerable amount of atmospheric electrical disturbance without getting out of order, and to preserve the coils of the electromagnets from fusing, a lightning protector is inserted in the circuit.

A modification of this apparatus has been adopted for recording the level of sewers. To a borough engineer, within whose district there is a low-lying portion liable to floods, this level recorder should be of great value, as it will indicate a rise in tenths of an inch, and even supposing it was beyond his power to prevent a flood, he would, at least, be able to warn inhabitants in the locality before the contents of the sewer appeared to tell their own tale. The utility of the indicator is, however, patent to anyone, and its application can be varied to suit almost any locality or liquid. If an automatic warning is required, it is easy to cause the dial hands to complete the circuit of an electric bell or bells at any given height of the liquid in question, this bell or bells being placed wherever required.

Finally, we may say that we have seen the whole of the apparatus at work in the showrooms of Mr. George Jennings at Lambeth, and have only stated what we know it will do. The mechanism is very ingenious and well thought out, and the electrical arrangements are good. The cost of maintenance should be but trifling, as there is nothing much to get out of order. The consumption of zincs in the two batteries is reduced to the smallest possible quantity in comparison with the work done. Probably the cost of the batteries per annum could be written down as a few pence.

Racing Horses on the Stage.—We gave some few months ago a short account of a revolving panorama effect on the stage by electric motors in the play of the "County Fair," in New York. The idea, it appears, has been taken up and adapted with very striking effect in Paris by MM. Montreal and Blondeau, in their play "Paris Port de Mer," at the Variété Theatre. Three genuine horses, ridden by three genuine jockeys, really gallop on the stage and make, as it were, the entire circuit of the racecourse at Longchamps. This is managed by having strong endless rolls of cocoanut matting moving across the stage floor and over rollers under the stage. These rollers are driven by electric motors, and when the band begins to move backward the horses have to move their feet, and are gradually urged to a gallop by the jockeys, when in reality remaining stationary in space. The background is formed of the panorama of Longchamps, which unwinds at the same time. The fence in front is seen also flying past, and completes the illusion. The endless belt unwinds at the rate of 3,200ft. per minute; in other words, 12 or 15 leagues an hour. The authors of this truly curious illusion are M. L. Brader, who constructed the tracks; M. Solignac, who installed the electric motors; and M. Justin. Engravings, giving details of the arrangement from *L'Illustration*, are given in the *Scientific American* for April 25th. The current for the motors, we learn from *Electricité*, is provided by the Feydeau central station, and amounts to the large current of 600 amperes—200 amperes per achine at 100 volts!

ARMATURE REACTION IN CONSTANT-CURRENT DYNAMOS.*

BY PROF. H. S. CARHART.

(Concluded from page 583.)

Such is the influence of the armature magnetism upon the field of generator. It not only weakens that field by introducing a counter M.M.F., but it weakens the field locally, by a deformation and scattering of the lines belonging to the field of the main magnet. Hence the flattening of the curves at the brushes, and the uniformity of field secured in their vicinity wherever they may be located.

Before leaving the curves of Figs. 5 and 7, it may be of interest to describe an additional experiment suggested by these curves. If two extra brushes are provided and made to bear upon the commutator at the highest and lowest points of the curve in Fig. 5 and Fig. 7, then substantially the same current will flow through this auxiliary circuit, whatever the load in the main circuit. To test this, two extra brushes were made to bear at points 80deg. and 260deg. distant from the main positive brush with nothing in the main circuit except the electro-dynamometer. The conditions were those of the outer curve of Fig. 5. The circuit of the two extra brushes was then closed through a resistance of 180 ohms, and it was found that a current of 3·3 amperes was maintained through it. At the same time there was no increase in sparking at the main brushes, and the potential difference between them rose from 124 to 162 volts, the current increasing from 10 to 12 6 amperes. The same experiment was tried with the conditions necessary to secure the second curve, the extra brushes being fixed at 60deg. and 240deg. respectively from the main brush. The current in the auxiliary circuit was three amperes, and that of the main circuit increased, but to a smaller extent than before. The contact of the small brushes with the commutator was not so good as it should have been.

The conditions requisite to maintain a sparkless commutator when the lead of the brushes is varied with a varying load, so as to maintain the normal working current, seem to me now quite clear. A fairly uniform field, with pole-pieces not too heavy, and an armature magnetically powerful relative to the field, will accomplish the result when the field magnet is magnetised to such an extent that it is no longer greatly sensitive to moderate changes in the current.

The really fundamental condition is not the one generally or universally laid down in the books—viz., that the brushes shall be only slightly in advance of the theoretical neutral line, or the line across which the impressed E.M.F. in each coil changes sign in passing. The brushes may be at any distance from the neutral line. The condition is simply that the counter E.M.F. generated by any coil as it passes under the brush shall be sufficient to offset the E.M.F. of self-induction, due to a reversal of the current in a coil in passing from one side of the brush to the other, and shall in addition cause the newly-directed current to grow to its normal value as the segment leaves the brush. This means that the field of force at the brushes shall be practically constant. This practical constancy is maintained in every well-constructed constant-current generator, with closed coil armature, by the magnetic influence or reaction of the armature itself, in flattening out and weakening the field at its poles. No special proportioning is necessary to accomplish this result since the old Langley machine, to which I have already alluded, shows the same property. It will govern from full load to no load without any marked sparking at the brushes in any position.

Individual machines of any type will have their own idiosyncrasies. The smaller patterns will sometimes spark more than the larger ones. Some will spark a little more at full load, and some more at no load, and very many do not spark at all when the brushes are in good order and properly set. With all such machines the diameter of minimum sparking is practically the diameter of commutation for the constant normal current. The brushes cannot be placed near the theoretical neutral line, a little in advance of the needle points between the poles, except at full load, for otherwise destructive sparking will ensue. So also if the field is separately excited, and the brushes are rocked forward on open circuit, furious sparking will take place. The coils are short-circuited then in an active part of the field, with no self-induction to overcome, and no armature poles to plough through the field and deform it, scattering the lines of force as they move forward.

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* Paper read before the

The change of voltage in the third brush circuit, whenever the main current varies from its normal value, suggests the practicability of utilising this relation for the purpose of securing automatic regulation of the current. This method I have tried with satisfactory success. The third brush circuit contained an electromagnet as a responsive device, and this served to bring into action either an electromagnetic motor or mechanical motor mechanism for rotating the brushholder. With the third brush two segments in advance of the main brush, or about 75deg., the following table of results was obtained, as lamps were cut in and out.

Lamps.	Amperes.	Lamps.	Amperes.	Lamps.	Amperes.
16	10	7	10·2	3	10
15	9·9	6	10·1	5	10·1
14	10	5	10	7	10·5
13	10·2	4	9·9	9	10·5
12	10·3	3	9·6	11	10·3
11	10·4	2	9·8	13	10·2
10	10·3	1	9·3	14	10
9	10·2	—	—	16	10
8	10·2	—	—	—	—

There was no sparking during the whole motion of the brushes. The practical constancy of current secured demonstrates the constancy of the field in the vicinity of the brush when the main current is at its normal value. This uniformity near the polar surfaces of the armature, in whatever part of the field these poles may be, demonstrates that the armature reaction in constant-current generators is of enormous importance.

If this third brush circuit is of such low resistance that the main current divides so that a material portion of perhaps 30 or 40 per cent. passes off through the third brush, then an increase of the total current through the armature is accompanied by an increased current from the third brush, since this current is merely a branch of the main current derived from the generator.

GLASGOW CORPORATION ELECTRIC LIGHTING.

[The following are the reports by R. E. Crompton, Esq., Prof. Jamieson, and Sir William Thomson, referred to in report by the Special Sub-Committee on Electric Lighting, and the discussion, given in our last issue.—Ed. *E. E.*]

I.—REPORT BY MR. R. E. CROMPTON.

In accordance with your instructions I send you my report on electric lighting. These instructions were that I should prepare a scheme for lighting, by electricity, the streets in the compulsory, or what I hereafter call the central area.

After meeting your engineer, Mr. Foulis, in the course of my visit to Glasgow, I saw two sites for the generating station, one lettered AA in the key plan, at the Partick disused gas works, nearly 4,000 yards to the westward of the central area; and the other one at the present gas works at Dalmarnock, lettered BB on the key plan, about the same distance to the south-east of the central area.

Acting in strict accordance with your instructions, I first prepared a scheme for furnishing 5,000 16-c.p. lamps, lighted simultaneously in the central area from Partick. I prepared a second one for lighting the same area from Dalmarnock, but as in both cases I find that the cost of the mains connecting the generating stations with the area was so great as to be disproportionate to the cost of the rest of the plant, I have prepared four other schemes with a view to ascertaining how far this cost of the mains can be reduced. Mr. Foulis informs me, in addition to the lighting of the shops and offices in the central area, there is likely to be a considerable demand for light in private houses in the district immediately adjoining Sauchiehall-street, which I hereafter call the Sauchiehall-street area, and in the district surrounding the park, which I call the western area.

I prepared the following alternative schemes for lighting these areas, which can be better understood by my key plan D:

1. That above mentioned for lighting the central area only from Partick.
2. Lighting the Sauchiehall-street and western area only from Partick.
3. Lighting the central area, Sauchiehall-street area, and the western area from Partick.
4. Lighting the central area only from Dalmarnock.
5. Lighting all three areas from Dalmarnock.
6. Lighting all three areas from a station centrally placed.

On the small key plan attached, the Partick central station is at the extreme left, and is marked AA. The Dalmarnock one is on the right lower corner, and is marked BB. The central station is in the centre, and is marked CC. The respective areas above mentioned are bounded by dotted lines.

The object of working out these six schemes was to enable me to lay before you their comparative advantages and disadvantages, the capital expenditure likely to be incurred on each, and the cost of production of the electric light by each of the six schemes at varying scales of output. I have attached three sheets marked A, B, and C, giving the result of my calculations. Sheet A is a tabular statement of capital expenditure. B is a tabular statement of what I call engine-room expenses—that is to say, the cost of working your plant within the engine-room. This portion of the cost, when calculated per unit, being pretty constant within wide limits of the scale of production; and C, the total cost of production showing first the general charges, secondly, the percentage charges for repairs, renewals, and interest on capital, all of which may be called fixed or standing charges, and which, when added to the engine-room expenses, give the total annual cost of production for any given output. I work this out in the case of the three partial schemes for 200,000 and 400,000 units per annum, and in the case of the three larger schemes, 200,000, 400,000, and 800,000 units per annum. In every case I have reduced the total cost of production into pence per net units sold, and these figures are given in bold type, and are an accurate measure of the comparative merits of the six schemes.

In the first five of these schemes I have used the method of distribution that was applied by me successfully at Vienna, and is known as the five-wire system. I use continuous currents at 450 volts, in combination with accumulators situated at several sub-stations. The pressure 450 volts is defined in the Board of Trade rules as a low-pressure system, and is perfectly safe. This pressure extends only from the dynamo station up to the terminals of the accumulators in the sub-stations, which are led away to the houses at half this pressure, and in the houses themselves at a quarter this pressure.

In scheme No. 6 I do not even propose to use the 450 volts but the ordinary three-wire system that I am using in Kensington and our other London stations, the pressure in the charging mains being 240 volts, and in the houses 100 volts. In addition to the three important sheets, A, B, and C, and the key plan D, I enclose sheets E, F, G, and H, which give in very full detail the method of working out the cost of the low-pressure network of conductors which distribute the electrical energy from the sub-stations to the consumers' houses. I may here remark that the cost of this portion of the system of electrical conductors, which it is convenient to call "the network," is common to all systems of electrical supply, whether the systems be high or low pressure, as later experience in the use of the high-pressure alternating current with transformers has shown that in future it is not safe or advisable to put the transformers in the consumers' houses, and that these high-pressure systems must distribute from transformer sub-stations by means of low-pressure network.

Although my instructions related more particularly to scheme 1—viz., that of supplying 5,000 16-c.p. lamps in the central area from Partick—yet as the result of my calculations show us very definitely that scheme 6 is so greatly superior to the others that I think it will be most convenient for me to describe in full detail scheme 6, and explain in what important points the other schemes differ from it.

Scheme 6.—Generating Central Station.

The Corporation to purchase land or pay ground rent for a site in a central position. The area required is about 550 square yards—that is to say, that a plot of land having a frontage to the street of 18 yards by 30 yards depth from front to back would be very suitable for the purpose. I have prepared complete designs to place on such a site the generating machinery which could supply at once 10,000 16-c.p. lamps burning simultaneously, allowing space for future extensions up to 25,000 such lamps. I have allowed £5,000 as the cost of a substantial building of three floors, with a chimney of 130ft. high. On the ground floor will be placed a range of boilers of the "dry back" marine type, each about 200 h.p., that is to say, having 1,000 square feet of heating surface. On the same floor arranged parallel to the boilers I place on substantial foundations a row of steam dynamos, each of 200 h.p. In addition to these I supply two smaller steam dynamos, each of 90 h.p.

My estimate of scheme 6 provides for six 200-h.p. boilers, five 200-h.p. engines, and two 90-h.p. engines. The engine and boiler room to be provided with suitable travelling crane and other necessary tools, also with the switchboards and instruments for measuring the current and distributing it to the mains. This ground floor may be partially or wholly sunk below the level of the street, if on account of lights it is desirable to keep the elevation of the building low. On the first floor, extending over the whole of the engine and boiler room, would be space for the home batteries of accumulators, and for stores and workshop. Over this can be placed rooms for the resident engineer in charge, and the offices.

I have taken great pains to estimate closely the cost of the plant and accumulators in this central station, and in order to do this I have taken advantage of the issue of specifications I had to make a few days ago for a large London central station, and have filled in the figures from tenders I then received, so that the prices of Sheet A may be taken to be correct for the month of June, 1890. I have allowed a sum of £1,600 for spare parts for the steam dynamos and for sundry small tools, which I think is an ample allowance for the purpose. I do not think that any other of the items in the generating plant require special notice.

A.—CAPITAL COST OF WORKS.

—	1. 5,000 lights, from Partick.			2. 6,500 lights, from Partick.			3. 10,000 lights, from Partick.			4. 5,000 lights, from Dalmarnock.			5. 10,000 lights, from Dalmarnock.			6. 11,000 lights, from central station.		
Generating Plant—	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Building, chimney, foundations, etc.	5,000	0	0	5,000	0	0	5,000	0	0	5,000	0	0	5,000	0	0	5,000	0	0
Three boilers, each of 1,000 square feet heating surface, at £581 each fixed	1,743	0	0	2,324	0	0	3,486	0	0	1,743	0	0	3,486	0	0	3,486	0	0
Two steam dynamos, 90 h.p., at £850 each fixed..	1,700	0	0	1,700	0	0	1,700	0	0	1,700	0	0	1,700	0	0	1,700	0	0
Two steam dynamos, 200 h.p., at £1,610 each fixed	3,220	0	0	4,830	0	0	8,050	0	0	3,220	0	0	8,050	0	0	8,050	0	0
Steam and exhaust pipes, feed pumps, tanks, etc., at 35s. per 1 h.p.	1,050	0	0	1,370	0	0	2,100	0	0	1,050	0	0	2,100	0	0	2,100	0	0
Switchboards, instruments, etc.	1,000	0	0	1,250	0	0	1,500	0	0	1,000	0	0	1,500	0	0	1,500	0	0
Travelling crane	200	0	0	200	0	0	200	0	0	200	0	0	200	0	0	200	0	0
Sundries, spare parts, tools, etc.	1,000	0	0	1,200	0	0	1,600	0	0	1,000	0	0	1,600	0	0	1,600	0	0
	£14,913	0	0	£17,874	0	0	£23,636	0	0	£14,913	0	0	£23,636	0	0	£23,636	0	0
Storage—																		
Accumulators at generating and sub-stations—Large cells, at £25; small, at £5. 15s.	£6,880	0	0	£6,880	0	0	£12,480	0	0	£6,880	0	0	£12,480	0	0	£5,600	0	0
Switchboard, coupling-up, instruments	900	0	0	900	0	0	1,800	0	0	900	0	0	1,800	0	0	500	0	0
Alterations to building for sub-stations	1,000	0	0	1,000	0	0	2,000	0	0	1,000	0	0	2,000	0	0	750	0	0
	£8,780	0	0	£8,780	0	0	£16,280	0	0	£8,780	0	0	£16,280	0	0	£6,850	0	0
Distribution—																		
Culverts	£6,858	10	0	£5,534	0	0	£10,404	0	0	£5,967	0	0	£11,346	0	0	£8,872	5	0
Service boxes	541	0	0	444	0	0	951	0	0	496	0	0	907	0	0	876	0	0
Cost of copper, in network	965	0	0	925	0	0	2,280	0	0	965	0	0	2,280	0	0	2,280	0	0
,, ,, feeders	850	0	0	2,585	0	0	3,645	0	0	695	0	0	3,533	0	0	2,763	0	0
,, ,, charging mains	7,650	0	0	2,520	0	0	10,080	0	0	6,090	0	0	12,380	0	0	1,370	0	0
	£16,864	10	0	£12,008	0	0	£27,360	0	0	£14,213	0	0	£30,446	0	0	£16,161	5	0
Total of contract work	£40,557	10	0	£38,662	0	0	£67,276	0	0	£37,904	0	0	£70,362	0	0	£46,647	5	0
Engineer's fees, drawings, superintendence	4,050	0	0	3,870	0	0	6,550	0	0	3,800	0	0	6,800	0	0	4,660	0	0
Total cost of works	£44,607	10	0	£42,532	0	0	£73,826	0	0	£41,704	0	0	£77,162	0	0	£51,307	5	0

SUB-STATIONS.

In scheme 6 I only propose to put down one sub-station, to contain two batteries of accumulators. Such a station may be placed at any convenient point near to the point where Buchanan-street crosses St. Vincent-street. The space for these two batteries being small, and there being no machinery in motion to create a nuisance, it is usually an easy matter to find such a station in the "back" land, even close to a better class of property. One floor, 20ft. wide by 50ft. long, is ample for the purpose, provided it is strong enough to carry the weight, and is fairly well lighted and ventilated. The accumulators which I propose to employ in the central station and at the sub-station would be those which are now being successfully used in four of the London stations. These accumulators were originally designed by Mr. Howell, of Llanelly, and have since been improved by myself, so that they are specially designed for this purpose of combined storage and distribution. They affect this in an exceedingly economical manner, with a minimum of electrical loss, and at a minimum cost for repairs and renewals of those parts which are ordinarily supposed to be of a perishable nature. Four years' experience of their use in London has shown that the cost of upkeep of this class of accumulator is far less than had hitherto been supposed to be the case. Up to the present the cost of repairs and renewals has not reached 10 per cent. of their first cost; but in view of the possibility of heavy repairs to the plates being needed after six or seven years, I am in the habit, in all my calculations, of allowing a sum of 14½ per cent. per annum as the cost of the upkeep of these accumulators and their stands, and I believe this to be a perfectly safe and outside figure.

DISTRIBUTION PLANT.

The distribution plant consists of the mains in the streets, the service boxes, and the connections to the consumers' houses. If the local circumstances in Glasgow will admit of the use of the system of bare copper conductors strained in culverts, which I have applied with such success in London, I should strongly recommend it. In order to avoid unduly lengthening this report, I attach a separate description and drawings of these culvert mains. In case, however, the local conditions at Glasgow are such that these culvert mains cannot be employed, I can use two other alternative methods of laying the conductors: one, that of drawing insulated cables into pipes laid in the streets; and the other, that of using the patent bitumen trough system, invented and successfully employed by Messrs. Callender in Liverpool, Birmingham, and other towns.

My estimates are worked out on the supposition that three-quarters of the laying will be carried out on the culvert system, and one-quarter on either the pipe or Callender system. The prices on which the cost of the culvert system has been worked out are obtained from actual experience in London, but we find that the cost in other towns, such as Northampton, is considerably less than in London, and it is possible that this may be the case in Glasgow. Whichever of the three systems, or if a combination of the three ystems is employed, in every case I propose to supply a large number of service boxes, or openings in the streets, at which ready access can be given to the conductors for the purpose of making the connections to the adjoining houses, or for repairing them, or withdrawing them and replacing them by others, in case this should be found necessary. All this can be done without further disturbance of the surface of the streets. I am strongly of opinion that such a provision is a necessary one in the case of electric lighting distribution plant, as it is impossible for anyone to say, with any degree of certainty, what number of houses facing the mains will eventually take the light. Actual experience in London has shown us that the attachment of the houses to the mains is a gradual process, and if it were necessary to open up the streets every time this is desired to be done, it would be an intolerable nuisance to the traffic, as well as spoiling the surface of the street. By my culvert system, combined with the pipe system above mentioned, I have succeeded in entirely avoiding this nuisance in London. Every alteration, or repair, or attachment that has been necessary during the four years the underground mains have been in use in the Kensington and Knightsbridge district, has been carried on at night without any disturbance whatever to the traffic of the streets. These connections to the consumers' houses can be made very readily from the service boxes, if these are situated in the pavement, as in London we only find it necessary to make an opening in the cellar of the adjoining house and insert the service wire through it, and thence lead it to any convenient point within the consumers' premises to the terminals and attachment to the meter, as is prescribed in the Board of Trade rules. From the foregoing description of my scheme 6, it will be seen that the generating and distributing plant I propose for use in Glasgow will be in all respects identical with similar plant that I have already in use in London. In preparing this scheme I have attempted no novelties, but have in all respects followed well-beaten paths, and as I have had extended experience in the working of this class of plant, I am able to give with great certainty the actual cost of producing the electrical energy from it.

SHEET B.—ENGINE-ROOM EXPENSES.

This portion of the cost of production can be estimated by us engineers with great certainty. It will be seen from my figures that the cost does not vary very greatly through considerable ranges of scale of output. After the consumption has once passed a certain comparatively low limit, the fuel, water, and petty stores used is almost directly proportional to the output in electrical units. The cost, however, of the labour item is greatly reduced as the output is increased, and will, I believe, be reduced to more than I have shown it in my table; but as my own experience in England so far only goes up to outputs of 200,000 units, I do not like to take advantage of the reduction in the labour item which, I believe, will take place at the larger output. The data I have assumed in preparing Sheet B is that coke at Dalmarnock, 2s. 6d. per Partick, 4s. 3d.; and at the central station, 5s. The figures were given me by Mr. Foulis, and the th assumed. The cost of water at 4d. per 1,000 gallons

B.—ENGINE-ROOM EXPENSES.

—	1. 5,000 lights, from Partick.	2. 6,500 lights, from Partick.	3. 10,000 lights, from Partick.	4. 5,000 lights, from Dalmarnock.	5. 10,000 lights, from Dalmarnock.	6. 11,000 lights, from central station.
A.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Fuel—Dalmarnock, coke ....2s. 6d.	—	—	—	135 5 0	133 5 0	—
Partick .. ..4s. 3d.	226 10 0	226 10 0	226 10 0	—	—	—
Bothwell-street ....5s. 0d.	—	—	—	—	—	266 10 0
Oil waste, petty stores, at ·07d. per unit............	58 6 0	58 6 0	58 6 0	58 6 0	58 6 0	58 6 0
Water, at 4d. per 1,000 gallons	23 0 0	23 0 0	23 0 0	23 0 0	23 0 0	23 0 0
Lighting engine-room, sundries, at ·025d............	20 16 0	20 16 0	20 16 0	20 16 0	20 16 0	20 16 0
Engine-room labour	375 0 0	375 0 0	375 0 0	375 0 0	375 0 0	375 0 0
	£703 12 0	£703 12 0	£703 12 0	£612 7 0	£610 7 0	£743 12 0
At 200,000 units output, the cost per unit ...	**·84d.**	**·84d.**	**·84d.**	**·74d.**	**·74d.**	**·89d.**
B.						
Fuel—Dalmarnock	—	—	—	266 10 0	266 10 0	—
Partick	453 0 0	453 0 0	453 0 0	—	—	—
Bothwell-street	—	—	—	—	—	533 0 0
Oil waste, petty stores	116 12 0	116 12 0	116 12 0	116 12 0	116 12 0	116 12 0
Water	46 0 0	46 0 0	46 0 0	46 0 0	46 0 0	46 0 0
Lighting engine-room, etc.	20 16 0	20 16 0	20 16 0	20 16 0	20 16 0	20 16 0
Engine-room labour	470 0 0	470 0 0	470 0 0	470 0 0	470 0 0	470 0 0
	£1,106 8 0	£1,106 8 0	£1,106 8 0	£919 18 0	£919 18 0	£1,186 8 0
At 400,000 units output, the cost per unit ...	**·665d.**	**·665d.**	**·665d.**	**·55d.**	**·55d.**	**·71d.**
C.						
Fuel—Dalmarnock	—	—	—	—	533 0 0	—
Partick	—	—	906 0 0	—	—	—
Bothwell-street	—	—	—	—	—	1,066 0 0
Oil, waste, etc.	—	—	233 4 0	—	233 4 0	233 4 0
Water	—	—	92 0 0	—	92 0 0	92 0 0
Lighting engine-room	—	—	20 16 0	—	20 16 0	20 16 0
Engine-room labour	—	—	560 0 0	—	560 0 0	560 0 0
			£1,812 0 0		£1,439 0 0	£1,972 0 0
At 800,000 units output, the cost per unit ...	—	—	**·545d.**	—	**·452d.**	**·59d.**

C.—TOTAL COST OF PRODUCTION.

General charges.	1. 5,000 lights, Partick.	2. 6,500 lights, Partick.	3. 10,000 lights, Partick.	4. 5,000 lights, Dalmarnock.	5. 10,000 lights, Dalmarnock.	6. 11,000 lights, central station
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Salaries	500 0 0	500 0 0	750 0 0	500 0 0	750 0 0	700 0 0
Ground rents of station and sub-station	300 0 0	300 0 0	400 0 0	100 0 0	300 0 0	400 0 0
Insurance	50 0 0	50 0 0	70 0 0	50 0 0	70 0 0	70 0 0
Law and office charges	250 0 0	250 0 0	300 0 0	250 0 0	300 0 0	300 0 0
	£1,100 0 0	£1,100 0 0	£1,520 0 0	£900 0 0	£1,420 0 0	£1,470 0 0
Repairs to plant and renewal—						
Buildings at 2½ per cent.	150 0 0	150 0 0	175 0 0	150 0 0	175 0 0	175 0 0
Boilers, steam dynamos, switchboards, etc., at 5 p.c.	490 13 0	583 14 0	941 16 0	490 13 0	941 16 0	851 16 0
Accumulators and stand, at 14½ per cent	1,000 0 0	1,000 0 0	1,800 0 0	1,000 0 0	1,800 0 0	810 0 0
Culverts, etc., copper, insulators, etc., at 1 per cent.	126 0 0	91 0 0	205 0 0	107 0 0	230 0 0	121 0 0
Iron pipes and cables, at 6 per cent..................	256 0 0	180 0 0	420 0 0	240 0 0	440 0 0	240 0 0
	£2,022 13 0	£2,004 14 0	£3,541 16 0	£1,987 13 0	£3,586 16 0	£2,197 16 0
Interest on capital	£1,580 0 0	£1,500 0 0	£2,550 0 0	£1,460 0 0	£2,700 0 0	£1,800 0 0
Cost, exclusive of engine-room expenses	£4,702 13 0	£4,604 14 0	£7,611 16 0	£4,347 13 0	£7,706 16 0	£5,467 16 0
Engine-room expenses—A	703 12 0	703 12 0	703 12 0	£610 7 0	610 7 0	743 12 0
200,000 units.............	5,406 5 0	5,308 6 0	8,315 8 0	4,958 0 0	8,317 3 0	6,211 8 0
Cost per unit	**6·5d.**	**6·3d.**	**10d.**	**6d.**	**10d.**	**7·4d.**
Engine-room expenses—B........	£1,106 8 0	£1,106 8 0	£1,106 8 0	£919 18 0	£919 18 0	£1,186 8 0
400,000 units	6,809 1 0	5,711 2 0	8,718 4 0	5,267 11 0	8,626 14 0	6,654 4 0
Cost per unit	**4·1d.**	**3·4d.**	**5·3d.**	**3·15d.**	**5·2d.**	**4d.**
Engine-room expenses—C	—	—	£1,812 0 0	—	£1,439 0 0	£1,972 0 0
800,000 units	—	—	9,423 16 0	—	9,145 16 0	7,439 16 0
Cost per unit	—	—	**2·85d.**	—	**2·75d.**	**2·25d.**

but [illegible] variation in these two assumed [illegible]lt. I have assumed the [illegible] water evaporated per pound of coke. This is on the safe side, as it is somewhat less than the figure furnished to me by Mr. Foulis. One thing we learn from Sheet B is the very small advantage you gain in reduc-

E.—DETAIL OF COST OF CULVERTS, ETC.

Section.	Distance in yards.	1st Scheme.	2nd Scheme.	3rd Scheme.	4th Scheme.	5th Scheme.	6th Scheme.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
AA to B	1,800	1,800 0 0	1,800 0 0	1,800 0 0	—	—	—
B to C	550	550 0 0	550 0 0	550 0 0	—	550 0 0	550 0 0
C to X	75	75 0 0	75 0 0	86 5 0	—	75 0 0	75 0 0
X to XG	275	275 0 0	275 0 0	315 0 0	—	275 0 0	315 0 0
XG to G	300	300 0 0	275 0 0	300 0 0	—	345 0 0	345 0 0
G to H	400	400 0 0	—	400 0 0	—	400 0 0	400 0 0
H to HK	100	100 0 0	—	100 0 0	—	100 0 0	100 0 0
HK to JQ	200	200 0 0	—	230 0 0	182 0 0	182 0 0	200 0 0
JQ to J	150	150 0 0	—	150 0 0	137 0 0	150 0 0	150 0 0
J to K	150	150 0 0	—	150 0 0	150 0 0	150 0 0	137 0 0
K to KO	100	91 10 0	—	91 10 0	91 10 0	91 10 0	100 0 0
JQ to N	100	91 10 0	—	100 0 0	91 10 0	100 0 0	91 10 0
N to M	150	137 0 0	—	137 0 0	137 0 0	137 0 0	137 0 0
M to J	100	91 10 0	—	91 10 0	91 10 0	91 10 0	91 10 0
M to L	150	137 10 0	—	137 10 0	137 10 0	137 10 0	137 10 0
L to K	100	100 0 0	—	91 10 0	91 10 0	91 10 0	91 10 0
KO to O	80	73 0 0	—	73 0 0	73 0 0	73 0 0	73 0 0
O to P	175	160 0 0	—	160 0 0	160 0 0	160 0 0	160 0 0
P to JP	75	68 10 0	—	68 10 0	68 10 0	68 10 0	68 10 0
J to JP	80	73 0 0	—	73 0 0	80 0 0	80 0 0	73 0 0
P to Q	250	228 0 0	—	228 0 0	228 0 0	228 0 0	228 0 0
Q to QQ	150	137 10 0	—	137 10 0	150 0 0	150 0 0	137 10 0
JP to R	250	228 0 0	—	228 0 0	250 0 0	290 0 0	228 0 0
A to Q	75	68 10 0	—	68 10 0	75 0 0	75 0 0	68 10 0
JQ to S	350	320 0 0	—	320 0 0	320 0 0	320 0 0	350 0 0
S to P	150	150 0 0	—	150 0 0	150 0 0	172 0 0	137 0 0
HK to VW	100	100 0 0	—	100 0 0	100 0 0	115 0 0	91 10 0
VW to T	250	250 0 0	—	250 0 0	250 0 0	290 0 0	228 0 0
T to TT	250	228 0 0	—	228 0 0	228 0 0	228 0 0	228 0 0
T to S	125	125 0 0	—	125 0 0	125 0 0	145 0 0	114 0 0
N to U	275	—	—	275 0 0	—	275 0 0	275 0 0
U to E	700	—	—	—	—	—	—
E to D	200	—	200 0 0	200 0 0	—	182 0 0	182 0 0
D to C	110	—	110 0 0	110 0 0	—	100 0 0	100 0 0
E to F	175	—	160 0 0	160 0 0	—	175 0 0	175 0 0
F to G	175	—	160 0 0	160 0 0	—	175 0 0	175 0 0
F to V	200	—	182 0 0	182 0 0	—	182 0 0	182 0 0
V to W	75	—	68 10 0	68 10 0	—	68 10 0	68 10 0
W to D	75	—	68 10 0	68 10 0	—	68 10 0	68 10 0
W to X	100	—	91 10 0	91 10 0	—	91 10 0	91 10 0
B to Y	175	—	175 0 0	175 0 0	—	175 0 0	175 0 0
Y to ZC	100	—	100 0 0	100 0 0	—	100 0 0	100 0 0
ZC to ZD	50	—	45 15 0	45 15 0	—	45 15 0	45 15 0
ZD to ZE	350	—	320 0 0	320 0 0	—	320 0 0	320 0 0
ZE, ZF, ZC	500	—	455 0 0	455 0 0	—	455 0 0	455 0 0
ZC to ZA	125	—	115 0 0	115 0 0	—	115 0 0	115 0 0
ZA to ZB	100	—	91 10 0	91 10 0	—	91 10 0	91 10 0
ZA to Z	100	—	91 10 0	91 10 0	—	91 10 0	91 10 0
Z to Y	125	—	115 0 0	115 0 0	—	115 0 0	115 0 0
BB to QQ	2,600	—	—	—	2,600 0 0	2,600 0 0	—
CC to G	150	—	—	—	—	—	300 0 0
		£6,858 10 0	£5,524 5 0	£9,764 0 0	£5,967 0 0	£10,696 15 0	£8,232 5 0

F.—SUMMARY OF COST OF CULVERTS, ETC.

—	1st Scheme.	2nd Scheme.	3rd Scheme.	4th Scheme.	5th Scheme.	6th Scheme.
Summary of cost of mains—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Culverts.. ..	6,858 10 0	5,524 5 0	9,764 0 0	5,967 0 0	10,696 15 0	8,232 5 0
Copper in network	965 0 0	925 0 0	2,280 0 0	965 0 0	2,280 0 0	2,280 0 0
Feeders	850 0 0	2,585 0 0	3,645 0 0	693 0 0	3,533 0 0	2,763 0 0
Charging mains	7,650 0 0	2,520 0 0	10,080 0 0	6,090 0 0	12,380 0 0	685 0 0
Total	£16,323 10 0	£11,554 5 0	£25,769 0 0	£13,715 0 0	£28,889 15 0	£13,960 5 0
					Error	......685 0 0
					Correct total	£14,645 5 0
With maximum load of Loss in mains=	500 amperes. 11·25 per cent.	650 amperes. 9·9 per cent.	1,000 amperes 9·7 per cent.	500 amperes 9·5 per cent.	1,000 amperes 17·25 per cent.	1,000 amperes 5·65 per cent.
Increased cost due to 1¼d. rise in copper	£1,125 0 0	£720 0 0	£1,905 0 0	£922 0 0	£2,170 0 0	£682 0 0
Length of culvert for charging mains ... Ditto network	3,475 yards 3,685 ,,	2,525 yards 3,185 ,,	2,525 yards 8,245 ,,	2,600 yards 3,685 ,,	3,325 yards 8,245 ,,	1,025 yards 8,245 ,,
Total	7,160 yards	5,710 yards	10,770 yards	6,285 yards	11,570 yards	9,270 yards
Cost of service boxes—in mains Ditto in network	£174 0 0 367 0 0	£126 0 0 318 0 0	£126 0 0 825 0 0	£129 0 0 367 0 0	£82 0 0 825 0 0	£51 0 0 825 0 0
Total	£541 0 0	£444 0 0	£951 0 0	£496 0 0	£907 0 0	£876 0 0

tion of engine-room expenses by placing your central station at Dalmarnock, the point at which fuel is cheapest. On the smaller scale of production, the difference is only ·15 of a penny, and the larger scale of production only ·16d.

Turning to Sheet C, it will be seen that at Glasgow the engine-room expenses bear a very small proportion to the total cost. I have assumed in Sheet C that the general charges will remain fixed through a very considerable range of output, although this is not strictly correct, as no doubt the salaries, law and office charges, and the repairs and renewals will be somewhat lower when the plant is partially worked than they would [illegible] worked at its full capacity; but as the amo is difficult to estimate, I thought it is safer to work out once for all the general charges and the repairs, and renewals and interest on capital, and divide the sum thus obtained out at three scales of production—viz., 200,000, 400,000, and 800,000 units per annum.

The method I have employed for working out the cost of repairs and renewals is that which has been used by several of the London companies. It is this. To set aside every year a percentage on the value of various portions of the plant, and from the sum thus produced to deduct whatever is spent in the current year on repairs, and place the balance, if any, to a renewal fund. By this method sufficient money is provided to keep the plant in its original condition—that is to say, in perfect repair for any period. The percentages are as follows: On the value of buildings, 2½ per cent.; on steam dynamos, boilers, steam-pipes, switchboards, and other machinery of the same class, 5 per cent.; accumulators, including stands and connections, 14½ per cent.; on distributing plant, all concrete work, copper, glass insulators, and such like imperishable materials, 1 per cent,; on ironwork and insulated cables forming part of the mains, 6 per cent.

The figures in bold type show in pence the cost per unit sold. The reason why the three incomplete schemes—1, 2, and 4—show the cost somewhat less than the three complete schemes, is that the partial schemes are not saddled with high renewal and interest charges. If, as no doubt will be the case, a portion of the generating plant were only put down in the first instance for schemes 3, 5, and 6, the cost per unit at the 200,000 scale would be reduced to about 7d. in the case of Nos. 3 and 5, and 4½d. in the case of No. 6. The figures on the sheet show very clearly what a large proportion of the cost of production of the electric light is due to upkeep and interest charges, and as the former is so high on the accumulators and so low on the mains, part of the favourable results shown by scheme 6 is due to the fact that I have been able to reduce very considerably the amount spent on the accumulators in proportion to the mains, so that there is a considerable reduction in the cost of upkeep in this item.

One point that has received my careful consideration is the probability that you will be able to obtain an output of 800,000 units per annum from the 10,000-light plant I have shown on schemes 3, 5, and 6. It is very difficult to predict this with any degree of accuracy, but, as far as London experience can guide us, the sale of 800,000 units from a plant capable of supplying 11,000 16-c.p. lamps (lighted at one time as a maximum) is a very reasonable estimate. A great deal depends on the extent to which the lamps are used simultaneously in the offices and shops and the private houses. If the hours of maximum supply in the offices and shops occur at an earlier hour than that of maximum supply in private houses, then it would be quite safe to attach 33,000 16-c.p. lamps to scheme 6; but if the hours of maximum supply coincide, then it would not be safe to attach such a large number to the system.

I have said nothing about the price to be charged for electrical energy, as I do not know whether the Corporation wish to make a profit on the sale of electricity or not; but there is a reasonable certainty that, at the scale I have shown, the electricity can be produced at the figures shown in bold type, and that the cost of the works will be as estimated. You will see in my estimated cost of the contract works, Sheet A, I have added an item of 10 per cent. for engineer's fees, drawing, and superintendence. This may appear excessive, but in this case, as throughout these estimates, I have given what I believe to be a safe figure. Moreover, as doubtless if these works are carried out by your Corporation the work will be done gradually, the cost of the engineering and superintendence will become somewhat higher than it would be if the work was given out in one contract and carried out in a year or so.

In conclusion, you will gather from my figures, and from my description, that I unhesitatingly prefer scheme 6 to all the other arrangements, and if there are not insuperable objections to obtaining a site in a central situation, I am strongly of opinion that the Corporation will be well advised to decide on this position for the site sooner than putting it at Partick or Dalmarnock.

R. E. Crompton.

II.—REPORT BY PROF. JAMIESON, M.INST.C.E., ON DIFFERENT SYSTEMS OF GENERATING AND DISTRIBUTING ELECTRICAL ENERGY FROM CENTRAL STATIONS.

Having visited and carefully examined six of the largest and best-appointed electric lighting central stations in the kingdom (every one carried out on a different system from the others), and having received and laid before you models, drawings, and prices of the most approved kinds of underground mains, I have now, in accordance with your instructions, the pleasure of submitting the following summary of the information obtained by me on the subject:

Direct Supply Low-Pressure System.

The "direct supply low-pressure system," as adopted at Liverpool, and St. James's, London, is both good and economical. But a slight variation in the speed of the engines instantly causes a corresponding variation in the light of the consumers' lamps. A complete stoppage, or even partial breakdown of the boilers or engines, or of the dynamos, etc., means a corresponding obliteration of the consumers' lights. In order to avoid this as far as possible, the companies adopting this system have to keep in perfect readiness spare plant, so that it may be started at a moment's notice to replace any faulty corresponding portions. The mere act of putting this spare plant into gear, or even the addition or subtraction of an engine or dynamo, to those already in circuit is, as a rule, rendered clearly visible by a fluctuation of the light supplied to the public.

Combination of Dynamos with Storage Cells.

The liability to alteration or extinction of the lights is, as far as possible at present, avoided by the employment of storage cells.

There are two practical well-tried methods, which I shall now describe to you, whereby storage cells may be employed to effect this desirable object.

One of these is adopted by Messrs. R. E. Crompton and Co. at Kensington, etc., and the other by the Installation and Maintenance Company at Chelsea, etc.

Both of these methods employ tubulous boilers, generating steam at about 200lb. pressure on the square inch, to supply high-speed vertical compound engines coupled direct to dynamos at the central station. In both systems, ammeters and self-recording voltmeters are used to register the pressure and current leaving the central station.

Here the similarity ends.

Mr. Crompton conveys the outgoing current at about 300 volts pressure by means of the three-wire system of bare copper mains arranged inside his patent concrete culverts, to sub-stations where large storage cells are kept always joined up in circuit with the dynamos at the central station, except during the hours of small demand for current.

These cells thus permit (when fully charged) of a large proportion of the current from the dynamos being sent direct from the central station to the consumers' lamps, and at the same time provide an automatic compensation against any reasonable fluctuation in speed of the central station engines and dynamos. Moreover, should the engines at the central station have to be stopped from any cause whatever, the cells at the sub-stations will supply the customers with current for a considerable time without their being aware of any of the changes being effected at the central station. Also, during the hours of small demand for current these batteries can and do supply current at the required voltage.

The Electric Installation and Maintenance Company convey their outgoing current from their central stations at about 1,700 volts through underground mains arranged upon Callender's bitumen and the Callender-Webber systems, to one-half of their several sets of batteries arranged at sub-stations in series. When this one-half of their battery system has been fully charged, then the other half is automatically brought into circuit with the dynamos at the central station, whilst the fully-charged set is automatically placed in direct circuit with the consumers' lamps by a most ingenious system of self-acting switches kept at the sub-stations in an adjoining room to the cells. Further, they employ at the sub-stations, when the demand for current is great, a system of continuous-current transformers, which are joined in circuit with the central station dynamos and the outgoing current from the cells to the consumers. These transformers automatically act along with the discharging half the cells, so as to deliver the current to the consumers at constant voltage. Only one attendant is employed at one time to periodically visit the sub-stations three or four times a day in order to see that things are going all right. But these automatic devices cost, at least, 10 per cent. of the whole outfit for the sub-stations, and consequently it is a matter for your consideration whether the advantages gained by the use of such devices and the disadvantages of their upkeep, compensate for the advantages gained by the more direct supply method employed by Mr. Crompton.

The High-Pressure Alternate-Current Transformer System.

In the "high-pressure alternate-current transformer system," of Mr. S. Z. de Ferranti, using 10,000-h.p. engines and an electrical pressure of 10,000 volts, there are immense possibilities as to the economical supply of electrical energy from a distant source of power. But this system, at such a high pressure, has scarcely had a sufficiently lengthy trial to warrant your recommending its adoption at present in Glasgow. Yet you have had working in the very centre of Glasgow for the last two years a central station, arranged upon the Ferranti system, with a lower voltage—viz., 2,400 volts, which has proved successful with overhead mains. These overhead mains will have to be replaced within two years by underground ones, by order of the Board of Trade. For high-pressure currents I have not met with any mains better than those devised by Mr. Ferranti.

Consumers' Meters.

Most of the central station electric lighting companies charge their customers for the quantity of electrical energy delivered through the customers' meters. Already there is a variety of such instruments, for which it is claimed that they will measure quite as accurately as gas meters.

Underground Electric Lighting and Power-Distributing Mains.

I have laid before you specimens of Siemens's, Crompton's, the India Rubber and Gutta Percha Company's, the Fowler-Waring Company's, and Callender's solid bitumen mains, with prices, and I have verbally explained to you the Callender-Webber and the Brooks's systems.

After very careful examination of the advantages and disadvantages of each kind, I am led to the conclusion that, for straight runs underneath the pavements of the streets, and for low-pressure supply, Crompton's concrete culverts, with bare insulated copper strip mains, are both the cheapest and the most elastic for extension. Where corners, crossings, and awkward bends have to be made, then Siemens's, or the India Rubber and Gutta Percha Company's best vulcanised indiarubber cables, drawn through pipes, or Callender's cables, may be used, as is found most convenient for each case.

III.—REPORT BY SIR WILLIAM THOMSON AS TO SYSTEM OF LIGHTING TO BE ADOPTED IN GLASGOW.

In accordance with your letter of the 6th of April, I had a conference on Friday last, the 17th, with the Sub-Committee on Electric Lighting, in the course of which I gave my opinion verbally on the points submitted to me in the memorandum which accompanied your letter. It was to the following effect:

1. For lighting the compulsory district, marked in the plan which accompanied your letter, the low-tension direct-current system is, in my opinion, for many reasons decidedly preferable to the high-tension alternate-current system with transformers, and is the system which ought to be adopted.

2. The method of distribution by feeders and distributing mains, patented by Edison for this country and America in 1882, ought to be adopted. It is adopted in the Kensington and Knightsbridge lighting, and in the Westminster Electric Supply. I do not know whether any claim for patent right has been made upon them by Edison or his agents. The method, which is of great importance, was certainly described quite clearly by Edison in his patents. It seems probable that the question will be raised by Edison's representatives in this country when the result of litigation regarding it in the United States is known. I gave evidence in the American case, at the request of the Edison Company, and I think it right to point out to the Glasgow Corporation that there is at all events a possibility of a claim for royalty for the use of the system having to be met.

3. The supply station ought to be as near as may be to the district to be lighted. The nearer the better for good economy.

4. A moderate amount of storage battery should be provided, about enough, perhaps, to serve well for several hours at about 15 per cent. of the maximum ordinary rate of consumption. This would allow all the engines of the central station to be stopped as a rule every day from 4 a.m. till 8 a.m., and for a longer time, at all events in summer, if desired. The Howell-Crompton type is the best hitherto produced for the purpose of town lighting from central stations, because it is especially adapted to work with moderately good economy, and without damage to itself, for about one hour or somewhat more at an abnormally high rate of action, and so to meet a sudden demand, such as that entailed by a fog coming on suddenly, and to give fairly well the requisite supply of light until steam can be got up and the engines working from the central station at full power.

5. If the lighting was to be confined to the compulsory district alone, and a central station is provided either within it or close to its boundary, the two-wire system would be preferable to the somewhat less simple three-wire system. But as large extensions to different parts of the town will no doubt be made, before long it is to be hoped, it would, I think, be right to begin at once with the three-wire system, with about 250 volts between the + and − mains, so as to be able to provide 110 volts for the houses.

6. In choosing a site for a central station, it is of great importance that there should be facilities, not only for carrying in coals but for carting away ashes, and as economically as possible, and with as little as possible of annoyance to the public.

If there are any other points at present on which you wish my opinion, let me know, and I shall give immediate attention.

COMPANIES' MEETINGS.

ANGLO-PORTUGUESE TELEPHONE COMPANY.

The adjourned fourth ordinary general meeting of this Company was held on Thursday week, Sir Alexander Armstrong, K.C.B., F.R.S., in the chair.

The **Chairman** stated that there had been a steady increase of business during the year, the amount to the credit of the profit and loss account, after making all deductions, and including the balance brought from last year, being £6,193. Out of that an interim dividend of 5 per cent. had already been paid, absorbing £2,500, and of the balance it was proposed to place £2,500 to reserve, and to carry forward £1,193. The subscribers had increased by 152, the extra value being £1,033. During the first five months of the present year they had also been doing an increased business. They had 1,085 subscribers at Lisbon and 1,009 at Oporto. The report and accounts were adopted.

CITY AND SOUTH LONDON RAILWAY.

An extraordinary general meeting of this Company was held on Tuesday at Winchester House, Mr. C. G. Mott, chairman, presiding. The business before the meeting was a proposal to increase the capital of the Company.

The **Chairman** stated that the capital was required for providing additional sidings at Stockwell, and for further engine power and rolling-stock. He considered that the working of the concern should be regarded as satisfactory, seeing that they had had to educate a staff in the new power with which they worked their system—namely, electricity. The electrical engines had not been equal to the power expected, and they had therefore ordered other locomotives from different makers, which were guaranteed to give greater speed, and by which they hoped they would be enabled to improve their service and run the trains more frequently. During the time the line had been opened they had carried 3,000,000 passengers in perfect safety. After due consideration of the question they came to the conclusion that the best way of raising the additional capital which they now required—namely, £50,000—was by an issue of preference shares. He thought that the result attending their operations, bearing in mind that theirs was a new line, must be regarded as quite satisfactory. They were earning an income at the present time at the rate of £40,000 a year, and, after meeting all expenses, they estimated that this amount left a net profit of £12,000, a sum which, though small, was sufficient to cover their debenture interest, and to leave a surplus of between £3,000 and £4,000. They would, he hoped, be able during the next year to increase their receipts and reduce their expenditure, and they might then be able to pay a moderate dividend upon their ordinary share capital. He thought that they must regard the working of their system, and the results attending it, as satisfactory. He concluded by proposing the following resolution: "That the resolution passed at the general meeting of the Company held on August 12th, 1890, relating to the creation of the new capital authorised by the City and South London Railway Act, 1890, be, and the same is hereby, cancelled and annulled, except as to the creation and issue of 5,000 ordinary shares at £10 each, part of the total number of 20,000 shares authorised by the same resolution."

The motion having been seconded, objection was taken by **Mr. Court** to the issue of preference capital, and he proposed an amendment adjourning the meeting for 14 days.

The amendment was accepted by the Chairman after discussion, and on being put to the meeting was carried.

ELECTRIC AND GENERAL INVESTMENT COMPANY.

The second ordinary general meeting of this Company was held at Winchester House on Wednesday, the Duke of Marlborough chairman, presiding. The report and accounts were given in our last issue.

The **Secretary**, Mr. J. Cecil Bull, having read the notice convening the meeting,

The **Chairman** said that they would see that the net profit which had been earned by the Company was £2,592, which would be distributed in the form of a 10 per cent. dividend, together with a bonus of 12s. 6d. per cent., and £266. 10s. 9d. would be placed to reserve, and in payment of £1. 5s. on each founder's share, and of £59 as additional remuneration to the Directors according to the articles of association. The business done had, in the nature of things, been small, that being the first year they had embarked upon the business. A great deal of credit was due to the persons who had been the moving spirits in that enterprise. The formation of the Company was attributable to two or three gentlemen who had foreseen the enormous development of the electric lighting industry which was taking place. It was seen that the ordinary financial houses were not generally conversant with electric light matters. The moment had, however, now come when the whole of electrical progress had reached a commercial basis. The last ten years had been a period of tentative progress, and had been marked by want of experience. But the failures had taught people the lines on which to proceed not only as to improved inventions, but also as to the commercial side of the matter. Very exact figures could now be given by engineers as to the cost of plant sufficient for a given number of lights, and for lighting a certain area; and they could calculate the profit that would be derived from the undertaking. The gentlemen, therefore, who proposed to invest their (the Company's shareholders) money in this form of undertaking foresaw that it would be very probable that large demands would be made for capital to carry out these various projects both in the City of London and the provinces. During the year's experience which they had gained they saw enormous promise of business in all directions—not only corporations but private persons were engaged in forming companies for the purpose of lighting towns, and as, they knew, provisional orders had been applied for all over England. The function of their Company was to try and set these enterprises on their legs, and on a thoroughly conservative and proper basis. It was not their wish to take undue profits out of any enterprise, but simply to employ their energies in floating these concerns—those that promised well—and to reject those which they did not think the time had arrived for pushing. The absolute business they had done during the year had not been very large, though looking at the amount of the capital that had been subscribed he dared to say they would be satisfied with the result. The condition of the money market had not been favourable during the last eight months. In a short time the electric light would be a serious competitor of gas, and in many places, and certainly in that city, it would probably supplant it altogether. It was more expensive than gas, but had enormous advantages. He moved the adoption of the report and accounts.

This was seconded by **Mr. Herring**, and carried unanimously.

The **Chairman** having answered questions as to when the dividend would be paid, and as to a Stock Exchange quotation for their shares, the Auditors were re-elected and the proceedings closed.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for last week were £5,670.

Western Brazilian Telegraph Company.—The receipts for the week ended June 12 amounted to £3,277.

City and South London Railway.—The receipts for the week ending 13th inst. were £860, against £776 for the week ending June 6.

NEW COMPANIES REGISTERED.

more Valley Electric Light and Power Supply Company,
ted.—Registered by Jordan and Sons, 120, Chancery-lane,
, with a capital of £10,000 in £5 shares. Object: the
ing on in the Ogmore Valley, and elsewhere in the county of
organ, the business of an electric light company in all its
hes. The regulations contained in Table A mainly apply.

COMPANIES' REPORTS.

SE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY, LIMITED.

rectors: Henry Ramie Beeton, chairman; Robert Arthur
aine, M.A., L.C.C.; Robert Hammond, managing director;
am Page, C.E. Secretary: H. St. John Winkworth.
port of the Directors for the year ending 31st December, 1890:
e Directors have pleasure in submitting to the shareholders
e form now prescribed by the Board of Trade) balance-sheet
rofit and loss account showing the operations of the Company
January 1 to December 31, 1890. After placing to capital
nt the debenture interest and loss on working to September
890, up to which date the business was being established, the
evenue account shows a credit balance of £385. 15s. 8d.,
h is carried forward to the next accounts. The period under
w has been mainly spent in building up the Company's
ess: the number of lights attached to the Company's circuit
nuary 1 being 4,520, and the number on December 31 being
5, pointing to the probability of good returns in future years.
is connection the following statement is interesting:

Date.		Working expenses.		Revenue.
ary to June, 1890	......	£1,921 0 7	......	£1,373 6 7
to December, 1890	......	£2,703 5 10	......	£3,637 2 7

e beginning of the year there were 78 houses connected to
ompany's circuits, and on December 31 there were 248
s The number of connected lamps, as already stated,
ecember 31 was 13,665, which has since been increased
,144 in 304 houses, whilst fully 4,000 more lights are
or are in process of wiring. The Company's mains.
ding to nearly nine miles, are now laid in the following
, etc.: Allan-terrace, Ashburn-place, Astwood-road, Bark-
gardens, Barkston-mansions, Bath-place, Bina-gardens, The
ns, Bolton-gardens West, Bramham-gardens, Bramham-
ions, Clareville-grove, Claro-terrace, Colherne-mansions,
rne-road, Colherne-terrace, Collingham-gardens, Collingham-
Collingham-road, Courtfield-gardens, Courtfield-road,
ey-gardens, Cranley-place, Cromwell-mansions, Cromwell-
Drayton-gardens, Earl's Court-road, Earl's Court-square,
n-gardens, Fopstone-road, Foulis-terrace, Fulham-road,
n-road, Gledhow-gardens, Gledhow-terrace, Gloucester-
ions, Gloucester-road, Gloucester-terrace, Harcourt-terrace,
ngton-gardens, Harrington-road, Hereford-square, Hogarth-
Kempsford-gardens, Kensington-road, Kensington-mansions,
esborough-place, Lexham-gardens, Marloes-road, Moreton-
ns, Nevern-mansions, Nevern-road, Nevern-square, Newland-
Newland-terrace, Old Brompton-road, Onslow-gardens,
w-square, Pembroke-gardens, Philbeach-gardens, Priory-
ns, Queen's-gate, Redcliffe-gardens, Redcliffe-square, Rich-
-road, Roland-houses, Roland-gardens, Rosary-gardens,
rset-terrace, Stanhope-gardens, Sumner-place, Sussex-
Trebovir-road, Tregunter-road, Warwick-road, Wetherby-
ns, Wetherby-road, York-mansions. With a view of pro-
g capital for the extension of the Company's business in
ngton, and in order to keep pace with the demand for the
an issue of 7 per cent. cumulative preference shares was
ioned in December last by the shareholders. The depressed
of the money market having interfered with the subscription
pital, the Directors will be glad if the shareholders will
nally interest themselves in this issue and subscribe the
sary amount to admit of the extension of the Kensington
n; a step which is necessary in order to comply with
obligations of the Company's provisional order and to
e a satisfactory return upon the capital already invested.
irectors are considering proposals for vesting the Company's
sts outside the metropolitan area in a construction company,
is hoped that a steady annual addition to the profits of the
any will accrue from this source. During the year Mr. F. J.
and Mr. C. T. D. Crews resigned their seats at the Board,
he vacancies were filled up by the election of Mr. W. Page
Mr. R. A. Germaine, who are the retiring Directors, and
eligible, offer themselves for re-election. At the meeting
areholders will have to elect Auditors for the ensuing year;
s. Theobald Bros. and Miall being eligible, offer themselves
election.
capital of the Company consists of 100 founders' shares of
d 5,322 fully paid ordinary shares of £5, the total paid-up
l being £27,110, and the amount still unissued £72,890, out
authorised total of £100,000.
statement of loan capital shows that 30,000 6 per cent.
tures have been issued, which are convertible into ordinary
, so that the total capital received is as follows: Total share
l paid up, £27,110; total loan capital borrowed £30,000;
apital received, £57,110.

CAPITAL ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Expenditure— Dr.	Expenditure up to 31 Dec., 1889. £ s. d.	Expended during the year. £ s. d.	Total expenditure to 31 Dec., 1890. £ s. d.
Lands, including law charges incidental to acquisition......	56 10 6		56 10 6
Buildings	8,052 12 4	220 5 1	8,272 17 5
Machinery	15,175 17 4	276 16 4	15,452 13 8
Mains, including cost of laying the mains	6,749 11 3	5,036 11 6	11,786 2 9
Transformers, motors, etc.	870 1 8	1,800 0 8	2,670 2 4
Meters.................	412 1 2	1,201 5 11	1,613 7 1
Electrical instruments, tools, etc...	232 3 7	163 6 10	395 10 5
Purchase of right of user of patents or patent rights and covenants with managing director	7,500 0 0		7,500 0 0
Cost of license, provisional order, etc.	1,537 7 7		1,537 7 7
Office furniture......		95 3 7	95 3 7
Foundation of business—loss on electricity account to Sept. 30, 1890, and debenture interest to that date		1,709 18 8	1,709 18 8
Total expenditure...	£40,586 5 5	£10,503 8 7	£51,089 14 0
To balance of capital account			6,545 6 0
			£57,635 0 0

Cr. Total receipts to December 31, 1890	£ s. d.
Ordinary shares of £5 each	26,610 0 0
Founders' shares of £5 each..................................	500 0 0
Debentures	30,000 0 0
Amounts received with applications for pref. shares	525 0 0
	£57,635 0 0

REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1890.

Dr. A.—To Generation of Electricity.	£ s. d.	£ s. d.
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	1,894 5 2	
Oil, waste, water, and engine-room stores	572 8 2	
Proportion of salaries of engineers, superintendents, and officers, as certified by the manager	177 16 0	
Wages and gratuities at generating station........	965 9 6	
Repairs and maintenance, as follows: Buildings, engines, boilers, dynamos, exciters, transformers, motors, etc., other machinery, instruments, and tools	296 5 0	
Cartage of ashes	58 19 9	
		3,965 3 7
B.—To Distribution of Electricity.		
Repairs and maintenance of mains of all classes		6 2 10
C.—To Rents, Rates, and Taxes.		
Rents payable	105 0 0	
Rates and taxes	93 3 10	
		198 3 10
D.—To Management Expenses.		
Directors' remuneration (special)	43 14 5	
Stationery and printing....................	65 10 4	
General establishment charges............	217 14 11	
Auditors of Company	31 10 0	
		358 9 8
E.—To Law and Parliamentary Charges.		
Law expenses		67 4 0
F.—To Special Charges.		
Insurances		29 2 6
Total expenditure		4,624 6 5
Balance carried to net revenue account		386 2 9
		£5,010 9 2

Cr.	£ s. d.	£ s. d.
Sale of electricity per meter at 8d. per B.T.U. (less discounts)	4,660 9 7	
Sale under contracts	30 14 5	
		4,691 4 0
Rental of meters, and other apparatus on consumers' premises		266 5 2
Transfer fees....................................	1 2 6	
Students' instruction account	51 17 6	
		53 0 0
		£5,010 9 2

NET REVENUE ACCOUNT.

Dr.	£	s.	d.
Balance from last account	23	9	3
Interest on debentures paid and accrued to date	1,661	16	6
Subscription Electrical Association	25	0	0
Balance carried forward	385	15	8
	£2,096	1	5

Cr.	£	s.	d.
Balance brought from revenue account (No. IV.)	386	2	9
Foundation of business, including loss on electricity account to 30th September, 1890, and debentures interest to that date, carried to account No. III.	1,709	18	8
	£2,096	1	5

GENERAL BALANCE-SHEET.

Dr. Liabilities.	£	s.	d.	£	s.	d.
Capital: 8,322 ordinary shares of £5 each	41,610	0	0			
100 founders' shares of £5 each	500	0	0			
Amounts received with applications for preference shares	525	0	0			
				42,635	0	0
300 debentures of £100 each				30,000	0	0
Sundry creditors on open accounts				7,797	13	10
Net revenue account: Balance at credit thereof				385	15	8
				£80,818	9	6

Cr. Assets.	£	s.	d.	£	s.	d.
Capital account: Amount expended for works as per account No. III.				51,089	14	0
Construction business development account*				14,831	17	1
Preliminary expenses, including canvassing and loss on installation business				3,759	5	11
Debenture issue expenses				153	13	2
Preference share issue expenses				65	5	4
Stores on hand at 31st December, 1890:						
Coal	80	17	0			
Oils, waste, etc.	59	9	9			
General	3,152	12	6			
				3,292	19	3
Sundry debtors on account of contracts in course of completion				359	10	10
Sundry debtors for electricity supplied to 31st December, 1890				2,918	16	8
Other debtors				3,386	1	0
Insurance premiums prepaid				39	0	6
Cash at bankers:						
Messrs. Glyn, Mills, and Co.	824	3	6			
Alliance Bank, Limited (Earl's Court Branch)	55	10	4			
Cash in hand	42	11	11			
				922	5	9
				£80,818	9	6

* This expenditure includes advances to sub-companies for applications for provisional orders and other purposes, and the acquisition of founders' shares in the following House-to-House Companies: Scottish, Lancashire and Cheshire, Yorkshire, Northern, Liverpool, Birmingham, Manchester, Midland, Western, South of England, Devon and Cornwall Electricity Supply, Sunderland and District; and provisional orders for Wandsworth, Lambeth, and Islington.

PROVISIONAL PATENTS, 1891.

JUNE 8.

9652. **Improvements in the production of copper tubes by electrolysis.** Alexander Watt, 81, Fernlea-road, Balham.

9683. **Improvements in electric primary batteries.** Thomas Joseph Davis Rawlins and Archibald Walker, 1, Quality-court, London.

9689. **Apparatus for supplying depolarising or other liquids to a series of electric batteries.** Victor Jeanty, 46, Lincoln's-inn-fields, London.

JUNE 9.

9734. **Improvements in dynamic electric machines.** William Aldred, 5, Brightside-bank, Brightside, Sheffield.

9762. **Improvements in secondary or storage batteries.** Stanley Charles Cuthbert Currie, 323, High Holborn London. (Complete specification.)

9779. **Application of vibrating tongues to produce automatic resistances in telegraph lines.** Maurice François Frédéric Bellier, 28, Southampton-buildings, London.

9780. **An electric regulator.** Peter Valentine McMahon, 28, Southampton-buildings, London.

9791. **Improvements relating to carbon electrodes for electrolytic and other purposes.** James Greenwood, 4, South-street, Finsbury, London.

9803. **An improvement in galvanic batteries.** William John Engledue, 115, Cannon-street, London.

JUNE 10.

9817. **Improvements in apparatus for inducing electric sparks for gas lighting and like purposes.** Alexander Reid Molison, 35, Terrace-road, Swansea.

9868. **Improvements in or connected with electrical signalling to and from trains.** John Orme, 65, Barbican, London.

9876. **Improvements in telegraph block systems of railway traffic control.** David Colin Coombes and William Rowe, 45, Southampton-buildings, London. (Complete specification.)

JUNE 11.

9887. **Improvements in and relating to microphonic or telephonic transmitters.** Arthur Thomas Collier, 45, Southampton-buildings, London.

9915. **Improvements in electric measuring instruments, electric safety fuses, manufacture of incandescent lamps, telephone transformers, electric organs, transformer distribution, envelopes.** James Swinburne and H. Sherwin Holt, Broom Hall Works, Teddington.

9928. **Improvements in galvanic batteries.** Gustave Adolphe Schoth, 33, Chancery-lane, London. (Complete specification.)

9938. **Improved apparatus for consolidating metals during the process of being deposited from an electrolyte.** The London Metallurgical Company, Limited, and Sherard Osborn Cowper-Coles, 80, Turnmill-street, London.

JUNE 12.

9955. **An improved electricity meter.** Sydney Holmwood Holden, Bell-lane, Erdington, Birmingham.

9956. **An improved electricity meter.** Robert Holden Housman, Perry Hall, Bromsgrove.

9997. **Improvements in pipes or tubes for conveying liquids and gases and for protecting and insulating electric conductors and for other like purposes.** John Armstrong, 7, Staple-inn, London.

10016. **A new or improved dynamo-electric motor or generator.** Alfred George Melhuish, 208, Choumert-road, Peckham, London.

10023. **Improvements in or relating to telegraph relays.** William Phillips Thompson, 6, Lord-street, Liverpool. (Robert O. Wickes, United States.)

10030. **An improved device for obviating sounds produced by the vibration of electric conducting wires.** Carl Rieger, 45, Southampton-buildings, London.

JUNE 13.

10069. **Improvements in or relating to electric bells.** Albert Hoster, 51, Cannon-street, London.

10082. **An improvement in voltaic batteries.** Paul Jablochkoff, 28, Southampton-buildings, London.

10083. **An electrical safety cut-out.** Henry Sheehy Keating, 28, Southampton-buildings, Chancery-lane, London.

10090. **An improved process for the electrolytic production of aluminium.** Ludwig Grabau, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1890.

9275. **Driving dynamos.** Williams. 4d.

9411. **Telephone plugs.** Fitzsimon. 6d.

10187. **Electric generators.** Thompson (Stanley and another). 8d.

12352. **Electric contact maker.** Bagnold. 6d.

20522. **Electrical indicating, etc., system.** Haight. 1s. 5d.

1891.

860. **Electric bell repeater.** Bagnold. 6d.

2334. **Electrical communicators for vehicles, etc.** Eyre and Graham. 6d.

3361. **Producing stereotype matrices, etc.** Newton (The Electric Typographic Company). 2s. 4d.

4263. **Telephones.** Wright and Wilson. 8d.

4838. **Incandescent electric lamps.** Bailey and Warner. 6d.

6881. **Covering electric wires.** Walcott. 8d.

6963. **Staying telegraph posts, etc.** Spagnoletti. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	1⅞
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9½
London Electric Supply	5	2¼
Swan United	3½	4½
St. James'	—	6½
National Telephone	5	4⅞
Electric Construction	10	7½
Westminster Electric	—	4¾

NOTES.

Bromley.—The oil lighting at Bromley, Kent, is to be discontinued.

Electric Bell Ringing.—The bells of Frinton Church are to be now tolled by touching an electric button.

Brussels.—Copies of the scheme and conditions for the lighting of Brussels can be obtained at 11A, Rue de l'Etuve, Brussels.

Exhibition at Strasburg.—An exhibition of machinery will be held at Strasburg, from June to the end of September.

St. Pancras.—As will be seen elsewhere, a competent electrical engineer is required by the St. Pancras Vestry, at a salary of £250 per annum.

The Society of Arts Medal has been awarded, amongst others, to Prof. Wm. Robinson for his paper on "The Use of Petroleum in Prime Motors."

Accumulator Cars in Paris.—The experiments on accumulator cars, says *Electricité*, have been entirely left off at the depots of the Compagnie des Omnibus.

Cable to Porto Rico.—The question is again being discussed of a cable between Spain and Porto Rico. The conditions can be obtained of the Spanish Minister of Colonial Affairs.

Electric Tools in Japan.—It is stated that at a works in Tokio, Japan, where large forgings are dealt with, the planing and drilling machines are now driven by electric motors instead of steam.

Kensington Mains.—The sanction of the London County Council is given to a proposed extension of mains in Queen's-gate by the Kensington and Knightsbridge Electric Lighting Company.

Aberavon.—At the monthly meeting of the Aberavon Town Council last week, it was decided to obtain from Mr. J. C. Howell, Llanelly, a report as to putting up electric plant as auxiliary lighting power.

French Contracts.—Conditions for tenders for gutta-percha and cotton covered wires and telephonic apparatus for the French Government, can be inspected at 103, Rue Grenelle and the chief post office.

Society of Arts.—The annual meeting of the Society of Arts revealed a highly satisfactory financial state, the society having a total revenue last year of £10,225, and a funded property (exclusive of trust funds) of £13,000.

An Electric Writing Instrument.—The test of a writing telegraph instrument, says Dalziel, was made between New York and Chicago on Saturday night, when 60 words were sent without a break by an automatic pen attached to a transmitting instrument.

Exhibition at Palermo.—Persons wishing to exibit electric motors and tools at the exhibition at Palermo should notice that applications are received till July 15. Correspondents' addresses are Vicomte Reverend, 1, Cité Gaillard, Paris, or M. Alex. Uttini, 10, Rue de Moscou, Brussels.

Artificial Lines.—*Electricité* for June 20th gives details and illustrations of artificial lines for testing made by MM. de Branville and Anizan—an underground line of 50 kilometres and an overhead line of 500 kilometres, embodying the resistance and electrostatic conditions of both.

Electricity in Photography.—At Düsseldorf, electricity has been employed indirectly in the instantaneous photography of large assemblies. Eight immense lamps of magnetism were instantaneously illuminated by electric means, and the photograph was taken, one over 600 persons.

Magnetisation of Nickel.—One of the most interesting of the exhibits at the Royal Society *conversazione* last week was Mr. Shelford Bidwell's nickel pendulum, arranged to show that nickel, which at ordinary temperatures is magnetisable, loses its power of being magnetised when heated to 300deg. C.

Physical Society.—To day (Friday) at the Science Schools, South Kensington, at 5 p.m., Prof. Ayrton and Mr. T. Mather will give a paper on "The Construction of Non-Inductive Resistances." Mr. C. V. Boys will read a paper on "Pocket Electrometers," and Mr. J. Enright on "Electrification due to the Contact of Gases with Liquids."

Franco-Danish Cable.—The second cable between France and Denmark, intended to duplicate that now existing between Oyne, near Calais, and the Island of Fanoë, in Denmark, will be laid on July 10 to August 1 between these same points. This new cable will give more direct communication of French messages for St. Petersburg. It is the property of the Compagnie des Télégraphes du Nord.

Gainsborough.—The Gainsborough Town Council are of opinion that the price of gas might be reduced, seeing that the company pay 10 per cent. and bonuses. In a discussion on this question Mr. Shipham proposed oil or electric light. The chairman thought there were plenty of companies willing to undertake the public lighting, and the matter was left in the hands of the surveyor to make enquiries.

C. & C. Motors.—These motors, invented by Prof. Crocker and Mr. Wheeler, have had an enormous success in America, and their sale by their agent in England, Mr. Shippey, has, we believe, risen to several thousands. We notice that M. E. H. Cadiot has undertaken to popularise them in France, and an article from his pen, fully illustrated, sets forth their many advantages for small powers in the *Revue Industrielle.*

Books Received.—We have received "Dynamo Construction—A Practical Handbook for Engineer-Constructors and Electricians-in-Charge," by John W. Urquhart (Crosby, Lockwood); "An Introduction to the Mathematical Theory of Electricity and Magnetism," by W. T. A. Emtage, M.A. (Clarendon Press, 7s. 6d.); "A Manual of Practical Electro-Therapeutics," by Arthur Harries, M.D. H. Newman Lawrence, M.I.E.E., (Sampson Low, 1s. 6d).

Electrical History.—Mr. P. F. Mottelay is carrying on from week to week in the *Electrical World* his interesting *résumé* of the historical relics or references of electrical science from the earliest times. This week he gives an abstract of Gilbert's "De Magnete," with a reprint of his frontispiece and references to Kepler and Bacon, and also to Savinier Cyrano de Bergerac—the latter being the French author who in 1650 gave a very clear hint of Edison's phonograph.

Electric Supply.—Notices have been sent to the County Council of the laying of service electric mains, from the Electricity Supply Corporation, to 50, Strand, and to the Camera Club and Messrs. Kegan Paul and Co.'s premises, Charing Cross-road; from the London Electric Supply Corporation, to the Prince of Wales Theatre, Coventry-street, to the Lyric Club, Whitcomb-street, and to 13 and 96, High-street, Deptford, and to 144, Regent-street, and 50, Parliament-street.

South London Railway.—Mr. Justice Kekewich, with reference to the question of nuisances reported last week, said that on the materials before him he should have difficulty in believing that the engines did not cause a nuisance. Then there was the question of the effect of the statutory powers conferred on the company. His Lordship directed the case to stand over to see whether the company could not reduce the nuisance caused by the engines; either party to be at liberty to apply to restore the case to the paper.

The Schoolmaster Abroad.—Our contemporary *Tit-Bits* is a successful publication, but its success is hardly due to its scientific knowledge. In reply to a question it says: "Cyclists run little or no danger of being struck by lightning. Steel, of course, is liable to attract, but cycles nowadays are nickel-plated all over, and nickel-plate does not attract lightning. Cyclists are, therefore, as safe as pedestrians, for lightning usually strikes the highest objects." This conclusively proves that if spires and chimney tops are nickel-plated they will be safe from lightning!

Notting Hill Mains.—The sanction of the London County Council is given to the Notting Hill Electric Lighting Company to lay mains in Addison-road, Holland-road, Napier-road, Melbury-road, Holland Villas-road, and Holland Park-road, upon condition that the cover stones of the culverts under 20in. wide shall be not less than 2in. thick, and of the wider culverts not less than 2½in.; and that where the culvert crosses the carriageway there shall be at least 9in. thickness of Portland cement concrete above the cover stones of the culvert, in addition to the road material.

Signalling at Sea.—Mr. J. W. Hayward, of St. John's, Newfoundland, is intending to demonstrate the utility of his invention for signalling at sea. The apparatus is a combination of lantern and keyboard for throwing alphabetical signs upon a white screen, which can be plainly read, it is claimed, at a considerable distance. It would seem a favourable occasion also for testing, by practical men, of the Danish system of flashing Morse signals from lighthouses to be read by means of a suitable telescope with spectroscopic attachment, proposed and practically carried out, to which attention was drawn some months ago.

Telephone Exchanges.—In the House of Commons, on Friday, Mr. Raikes, replying to a question by Dr. Cameron, said it was the fact that one or more of the patents for the telephones in use in this country expired in July. The question of the relation of the Post Office to the telephones was one of great complexity, as well as great importance. It was more than a departmental question, and the circumstances were occupying the anxious attention of the Government, but they had not yet come to any final arrangements as to the course to be pursued. He should be glad to give further information as soon as he was in a position to do so.

Westminster Mains.—Notices have been given to the London County Council by the Westminster Electric Supply Corporation of intention to lay mains in Allington-street and in Tothill-street. The proposed works are of the same character as those of this company which have been approved by the Council, and the committee recommend that the sanction of the Council be given upon condition that the company give two days' notice to the Council's chief engineer before commencing; that the mains be laid under the footways wherever it is found practicable to do so; and that the covers of the street boxes to be used shall consist of iron frames filled in with material to suit the paving.

Liege.—The committee which some time ago was appointed at Liège to consider the question of electric light has presented its report. The committee is of opinion that it would be preferable to invite demands for the concession. The best solution would be, they consider, to allow a large station to be erected which would pay a royalty to the town; it would be wrong to fear the diminution of the receipts of the communal gas works, the result of the introduction of electricity seeming always to be followed by an increase in gas consumption. The scheme elaborated by the committee provides for underground mains in the centre of the town, and for overhead wires in the outskirts and suburbs.

Telephones and Tramways.—In answer to the imputation in the local Press of a not very strenuous opposition to the autocratic policy of the National Telephone Company to monopolise the earth as a return circuit, the secretary of the Birmingham tramway says that the clause was vigorously opposed, not only by the tramway company, but the Birmingham Corporation, and after the very clear evidence of the town clerk that the telephone had no statutory powers in the streets, they were much surprised at the decision of the committee. The tramway company is now considering the best course to pursue in the interest of themselves and the public with regard to this adverse decision, which will have to be reconsidered by the Committee of the House of Commons.

Electric Lighting of Carlow.—The whole town of Carlow was successfully lighted up by electricity by Messrs. J. E. H. Gordon and Co., Limited, at an early hour on Thursday morning. The electricity is generated by water power situated at Milford, five miles distant, and is conveyed to the town by overhead wires at 2,500 volts pressure. Converters fixed on the posts in the town reduce the pressure to 50 volts, and deliver the electricity to a system of bare copper low-tension mains carried on the same posts. The arc and incandescent lamps are both attached to this. The low-tension mains extend through 4¾ miles of streets, and the plant is sufficient for the whole public and private lighting of the town. The work was commenced in December last. We shall hope to give a fuller account of the works in a later issue

Regent-street Mains.—The Highways Committee of the London County Council have considered a notice from the St. James and Pall Mall Electric Light Company of intention to lay mains in Beak-street, Vigo-street, Sackville-street, Old and New Burlington streets, Savile-row, Cork-street, and Burlington-gardens. The company proposes to lay a new feeder of armoured Siemens cable, while the mains in the other thoroughfares referred to will be laid in the iron culvert ordinarily used by the company. In order to avoid prolonged interference with the traffic in Regent-street, they recommend that sanction be given, on condition that the company give two days' notice to the Council's chief engineer before commencing, and that the works in Regent-street, when commenced, be carried on without intermission by day and by night until completed.

Mutual Telephone Company.—The number of subscribers on this company's Manchester exchange, actually speaking on June 19th, was 366. They are being added to daily at the rate of 25 per week. The progress made might be quicker, but it is not desired to have more than 500 talking on July 30, as after that date the magneto transmitters, now being put in, are to be replaced by carbon ones. We understand that the Mutual Company will be prepared on July 31st with a sensitive and efficient transmitter made in accordance with one of the designs figured in Edison's tension-regulator patent, which expires on July 30th. Arrangements are being made to join up 50 subscribers per week after the change of transmitters has been effected, and erect trunk lines to and open exchanges in Bolton, Oldham, and many of the other Lancashire towns.

Electric Forcing of Lettuces.—It is believed that where it is profitable to grow lettuce under glass for market at all, the electric light may be profitably used as an auxiliary. Mr. W. Rawson, of Arlington, Mass., has experimented for a season—his results encourage him to continue. The Worcester County (Mass.) Horticultural Society have published an account of what Mr. Rawson (no relation, we believe, of W. and R.) has done in this direction. One house for forcing lettuce 200ft., by 24ft., was lighted by one arc light, and kept alight till midnight at the cost of about £3 a month. The crop of lettuces was advanced 20 per cent. in time. One week's advance in five is a great gain to the market gardener, and the experiment may lead to further testing of the electric forcing house, which, as our readers know, was originally suggested and tried by Sir William Siemens.

Jennings Liquid Level Indicator.—In our recent notice of this apparatus we alluded to its utility as an indicator of the level of sewage in places where there are steep gradients, or the land is waterlogged. One of these indicators has been employed in the Hornsey Local Board's district, and we are assured on good authority that it has been working very satisfactorily, and has been the means of detecting a partial stoppage in one of the main sewers. One difficulty met with, however, is the accumulation of heavy matter which surrounds the chamber in which the float is placed, although care is taken to prevent this by the insertion of a screen. The electrical portion of the apparatus has been working without a hitch for about 12 months and giving very clear diagrams. The wires are conveyed in pipes underground from the outfall sewer to the pumping station, where the indicator is placed, and run in the same pipe as the telephone and fire-alarm wires.

Street Lighting in France.—"They manage these things better in France." While Barnet was tossing and turning, worrying and fretting about the electric light, and finally rejected it, the following note will show the way that a similar little bit of lighting is carried out in France: The little town of Neuville-au-Bois (Loiret) has just adopted the electric light for its streets, and will shortly extend them to private inhabitants. At present the light comprises 38 30-c.p. lamps and two arcs of 10 amperes. All the lamps are run in series, on a silicious bronze conductor of 3 mm. diameter, placed above or along the houses. A constant current of 10 amperes is used at an E.M.F. of 470 volts. Series dynamos are used, running at a speed of 1,200 revolutions. The installation has been carried out for the town by the Paris firm of Clemançon. The first trial runs were entirely satisfactory, and the formal inauguration took place on 21st June to the satisfaction of the inhabitants and officials.

Guttapercha Insulation.—Herr Grawinkel, a well-known German electrician, has read an interesting note before the Electrochnical Society of Berlin upon the underground electric lines in Germany. Comparing the tests made last year with those laid previously, the author finds that the insulation of the old cables is superior to that of those recently laid. This he attributes to the inferior quality of the guttapercha consequent to the enormous demand and the diminution of the crop, the price having, indeed, almost doubled during the last four years. On the other hand, M. Lagarde seems to have come to the conclusion that the better the guttapercha the less the insulation. These two conclusions, thinks *La Lumière Electrique*, are contradictory in appearance only. The guttapercha of good quality always possesses a high insulating power, but less so, however, than that of inferior quality. The difference consists in that the insulating power of the good quality is permanent, while that of the bad quality rapidly deteriorates.

Incandescent Electric Light for Looms.—In a recent communication M. Brunet has pointed out the advantages of the use of incandescent lamps in woollen mills, and describes the arrangement adopted in a certain mill in France. The lamps, of 32 c.p., were mounted three in series, in order to diminish the expense of conductors, but he does not recommend the arrangement for imitation, as the economy is far from compensating the inconveniences which result therefrom. The dynamo requires 40 h.p., taken from the principal shaft of the factory; it supplies 100 amperes and 320 volts at 475 revolutions a minute. The first cost amounted to about £650, and the annual cost of maintenance is 3,804f. (£152), including 10 per cent. depreciation and 5 per cent. interest. The cost per carcel-hour is ·0042f. (this comes to about the same as ·0042d. per candle-power hour). M. Brunet remarks that there is a very great advantage in using the electric light where driving power can be obtained from the mill power, and the total annual duration of the lighting is sufficiently great.

Kingswood.—The contract for the public lighting of the streets came before the Kingswood Local Board at their meeting last week. The clerk mentioned that the Bristol Gas Company had written to the effect that they adhered to their previous offer for the supply of gas at 2s. 10d. per 1,000 cubic feet. Three tenders had also come to hand from electric companies; but one of these had not complied with the conditions stipulated. The other two were from Messrs. Parfitt and Son, of Keynsham, and Messrs. Christy and Son, of Chelmsford. The former firm offered on a seven years' contract 140 lamps, of 25 c.p., at £3. 11s. 8d. per lamp per annum; 20 lamps, of 125 c.p., at £7. 5s.; and four lamps of 250 c.p., at £14—a total of 164 lamps, at £698. 13s. 4d. Messrs. Christy tendered on a five years' contract, the number of lamps to be not less than the equivalent of 150 lamps of 30 c.p. each. Their prices were £2. 10s. per annum for each lamp of 15 c.p., £3. 5s. for 24 c.p., £4 for 30 c.p., and £5. 10s. for 48 c.p. It was thought by the members that it would be advisable to visit a district where Messrs. Christy had already the responsibility of the public lighting; and it was agreed to write to the firm to this effect.

Death of Weber.—The death is announced at Göttingen, on Wednesday, of Wilhelm Eduard Weber, one of the oldest and best known of the German scientific men. He was born at Wittenberg October 24th, 1804, and was therefore in the eighty-seventh year of his age. He was educated at Halle, where he was appointed professor at the age of 27, subsequently being called to Göttingen, a position he was called upon to resign in 1857 by reason of a protest made by the professors against some unconstitutional action of the Government. His researches into the laws of acoustics had already made him famous, as well as those into the theory and laws of magnetism. After being for some years appointed professor of physics at Leipzig, he was honourably restored, with others, to his former professorship at Göttingen. Working together with the famous mathematician Gauss on investigations into terrestrial magnetism (published in 1840), he tried in 1833 to establish a communication between their laboratories, and thus invented what is regarded in Germany as the first electromagnetic telegraph, though he did not realise the importance of the discovery. His researches into diamagnetism were also important. It was at one time proposed to call one of the electrical units by his name, and though this has not been universally carried out, the name of Weber will ever stand amongst electrical names of the highest rank.

Aberdeen.—We alluded last week to an amended scheme for the electric lighting of Aberdeen. Mr. W. B. Esson, who is the engineer referred to, furnishes us with details more explanatory of what is intended to be done than appeared in our note. The amended scheme costing something under £10,000, provides for only about half the plant and machinery that it was originally intended to put down. The report mentioned refers to a generating plant of 1,000 16-c.p. lamps capacity and 500 lamps storage capacity, and the reason the amount now is so large is because the storage capacity is proportionally very large for the generating plant; but at the beginning the accumulators will be used not only as battery reserve, but, so to speak, as generating reserve. The scheme includes two dynamos of 500 lamps capacity. Instead of having a further dynamo as reserve, with a small battery, a large battery of 500 lamps capacity is provided for. In case one dynamo fails, the other, together with the battery, will be sufficient to supply the whole 1,000 lamps it is proposed to supply. The storage capacity will not be further increased, although eventually the number of lamps will reach 5,000. Not only is the storage capacity large in relation to the generating capacity, but another matter makes the first cost rather more expensive—namely, that the conduits are large enough for three wires, although only two will be used at the start, and even the two-wire system is large enough for 2,500 lamps.

Faraday as an Elder.—Some curious reminiscences of Faraday are given, of all places, in the *Referee* by our humorous and pathetic friend "Dagonet" (Mr. G. R. Sims). It seems that the present Mr. Sims and his father knew the great man in a peculiar way. They were of the persuasion known as Sandemanian, and worshipped in a little court off Aldersgate-street. The Sandemanians were Bible Christians, and their faith was simple and primitive in the extreme. Michael Faraday was an elder of this chapel, with a butcher, a gasfitter, and a linendraper. In 1856 Faraday, on his own confession, was "put away" from them because his scientific researches had unsettled his belief. The gasfitter and butcher were shocked and stern. They all prayed for him, asking that light might be sent to his darkened brain. The prayers were answered. After a separation of some months, the great Michael Faraday—the man whom all the world delighted to honour—came back one day to the little meeting-house in Paul's-alley, and, standing up before the little congregation—the Sandemanians were a very small body—made full confession of his error with tears in his eyes. Everyone wept, and a blessed peace fell on the little meeting-house. Faraday Mr. Sims remembers best as an elder, though he often met him at the elder Mr. Sims's house at Peckham. He had a very winning way with children, and they all liked him. The Sandemanians liked him very much as a man, but they preferred the butcher as a preacher, and they considered it a terrible thing for a good man to devote himself to such doubtful subjects as electricity, instead of reading the Bible and being satisfied with things as they were.

City Arc Lampposts.—Some 25 of the proposed arc lampposts for the City of London lighting have been, or are to be, erected in the streets near the Mansion House for the inspection of the City authorities, the directors of the company, and the public generally. These lampposts are erected on temporary permission for the approval of the City authorities, and the design to be adopted has not yet been determined. We have already drawn attention to the desirability of having a really handsome and original design worthy of the City, and suggested the desirability of a competitive design from first-class designers for such an important undertaking as the erection of 800 posts for electric light throughout the City, and we understand that the various designs are to be submitted for approval of the authorities and the public. Some very handsome arc lampposts were specially designed for the streets of Berlin, which those who have not had the pleasure of seeing may find represented in the picture gallery of the German Exhibition—in a painting, No. 157, of a street in Berlin. We shall endeavour to publish proposed designs of the lampposts, which are, we understand, to be uniform throughout the City. It may be interesting to mention in this connection that the fine lampposts which grace the Albert-embankment were designed by Mr. Vulliamy, architect, and were cast by Messrs. Holbrook, founders, of Chelsea. This well-known design would be too heavy and elaborate for posts standing in the streets, being designed for erection on the wall of the embankment, but the success of the idea of having appropriate standards is here amply exemplified.

Mather and Platt's Catalogue.—The fourth edition of the catalogue of dynamos has been issued by Messrs. Mather and Platt, Salford. This little pamphlet is one of the most important publications in electrical engineering fields, dealing as it does with the Edison-Hopkinson and Manchester dynamos, the commercial efficiency of which are guaranteed to be from 90 to 94 per cent. according to the size of machine, "which is a higher efficiency," they claim, "than that recorded of any other dynamo manufactured in England, on the Continent, or in America." The public tests at which results of 93·23 per cent. for the dynamo, and 93·79 per cent. for the motor were obtained, are well enough known to electrical experts. The full particulars of these tests are given in the catalogue, as also the account of fortnight and three weeks continuous runs with these dynamos. It is found that one set of brushes are capable of lasting a year on a machine averaging a run of three hours a day. Not the least interesting is the combination of Willans engine and Edison-Hopkinson dynamo, of which the combined efficiency was 86·7 per cent. In this test the consumption of water per indicated horse-power was 21·6lb. and per electrical horse-power hour 25lb. The commercial efficiency on full load is 95·8 per cent. A large illustration is given of this engine and dynamo on toned paper. A noteworthy sentence is: "There is no sparking whatever between the brushes and the commutator. This objection is entirely avoided in the Edison-Hopkinson dynamos. Many dynamos can be referred to which have run continuously for years, and still show very little wear on the commutator. With care a single set of brushes will last a twelvemonth or longer." The use of the dynamo as a motor is specially insisted upon, and its great efficiency—93·79 per cent.—is claimed as far in advance of any other motor yet constructed. The advantages of electric transmission of power is forcibly pointed out with practical illustrations, and reference is, of course, made to the City and South London Electric Railway, the principal line at which they are in use. The Bessbrook and Newry Tramway is also referred to; the annual train mileage is 20,000 miles, the tonnage 15,000 tons, and number of passengers, 75,000. The trains consist of a passenger motor-car, and six trucks capable of carrying two tons of goods; the total weight of the train being 28 tons. The motors are capable of developing 25 h.p., and a maximum speed of 15 miles an hour. The line has been in successful operation for six years, and "the cost of haulage has not exceeded 3½d. per train-mile. Full list of prices, with dimensions and particulars, are given of the dynamo and motors up to 400 h.p.

ELECTRIC TRACTION.

VI.—AERIAL LINES.

It may perhaps be thought that railways built in the air, or at any rate above the ground level, would prove to be nothing but conceits of the imagination, as airy as the dreams that many an inventor has had with regard to the possibilities of rapid travelling for light passenger traffic.

Nevertheless, considerable progress has already been made in this direction; and owing to the genius and ability of Fleeming Jenkin, and others who have followed him, almost as much has been successfully accomplished by telpherage and its allied systems as by the methods capable of adoption in the case of ordinary tram lines on the ground level.

It is a question for serious thought by those who will have to construct our future light railways whether the system of telpherage in any of its forms cannot be adopted far more generally than may now appear likely. Not only can such lines be used for passenger traffic, but they are also capable of enormous development for light goods or parcel conveyance, acting as feeders or branches to any great main line or trunk route.

The advantages of a telpher system are many and important. Before discussing these, however, it may, in the first place, be described somewhat briefly. It comprises stationary overhead wire ropes or rails, properly supported at intervals by suitable uprights sunk in the ground, along which are caused to travel electric locomotives, each drawing after it a train of cars or waggons. The whole system is perfectly automatic so far as regards the running of trains: the lines are divided up into sections, each one of which is cut off from the supply of electric current for the locomotive motors whenever the section in front is occupied by a train.

Two trains therefore cannot ever come within a complete section of one another, and an automatic block system is thereby obtained, wherein there is no dependence whatever upon the careful brains and ready eyes of the signalmen.

Returning now to the advantages of such a system, we may briefly sum them up as follows:

First, the initial outlay need be but small on a telpher line. The land is not cut up by huge ditches and tunnels, or covered over with large embankments. At the most, there are only required a few insignificant holes in which to insert the uprights that carry the wire rope, rod or rail track. If the line runs over an agricultural district, as would often be the case, the soil can be cultivated up to the very feet of these uprights, and little damage is therefore done to property.

Secondly, the levels of the line itself can be very easily kept constant by simply varying the height of the uprights, and the contour of the land becomes therefore almost a matter of indifference. Curves also are to a large extent avoided, as the line can be taken straight across country without regard to the ground or surface gradients.

Every engineer will appreciate a point of this kind as having a most important effect upon the working expenses.

"Many properties, especially mines and plantations, remain undeveloped or are hampered owing to the great cost of carriage either to the coast or nearest railway line. The essential characteristic of telpherage being its great economy, a means is thereby presented by which a difficulty of this kind can be dealt with."

For developing traffic in light goods it is not easy, therefore, to arrange or devise a better system than telpherage; but besides this there comes the question of rapid transit for passengers.

There is, as every railway engineer knows, a practical maximum of speed for locomotion by steam power. Not only does this depend upon the conditions inherent in the locomotive itself, but a great deal also hangs on the present system of two surface rails on which the trains may run. To travel at a speed of, say, double the present average velocity, would imply the utmost danger of trains leaving the metals, with the methods now in use. Accordingly it may be well worth while for the travelling public, whose descendants without doubt will in a generation or so consider our present speed of transit to have been extremely slow, to accustom themselves to possibilities in the way of developments in electric railways, so far as rapid transit is concerned.

These developments may perhaps take the form of elevated lines composed of at least three rails, and representing in section somewhat the appearance of the letter A at each standard; that is, one rail would be placed at the vertex, and two others at a lower level, one on each side. On these three points the train cars (which practically fit like a cap on the wedge-shaped section line) should travel so securely that it would become almost impossible for any train to be derailed whatever its speed.

Another plan is to allow the train cars (which are shaped in a peculiar fashion at each end so as to diminish air resistance as much as possible) to run upon large wheels in a kind of skeleton framework erected on massive standards, rails of the usual type being, of course, fixed along the bottom of the framework, and to the roof also, if deemed necessary, for additional steadiness or easy running. On an experimental line of this nature a speed of as much as 120 miles an hour has already been obtained without much difficulty.

VII.—THE BROAD AND GENERAL ADVANTAGES OF ELECTRIC TRACTION.

The reason for the rapid adoption of electric power by street railway men is readily understood when it is seen to offer more efficient service than animal traction, the wire rope or cable, and the steam motor; whilst, at the same time, the working expenses can be made less than with any of these other methods.

As compared with animal power, electricity—especially in the case of city tramway lines—gives the great advantages of quicker transit, cleaner streets, better systems of paving, and the substitution of mechanical power to do the work which at times necessarily entails severe overwork upon car horses.

Steam power on street tramway lines is open to very serious objections: there is a great deal of smoke and noise accompanying the use of even the best and most efficient type of steam tramway locomotives, which have, moreover, extremely low efficiencies as compared with the large and economical fixed engines usually employed in the electric power station. Finally, the weight of these heavy locomotives and vibrations of their working parts exercise a very deleterious effect upon the rails, which constantly need attention and renewals at considerable cost for labour and material. Electric cars have no such disadvantages.

In the third place, when instituting a comparison between cable or wire rope traction methods and those which employ electric energy, there will be seen the following points of difference between the two, electricity having an advantage on each single head:

1. There is a danger in cable traction of cars being unable to detach themselves, when required, from the moving rope, owing to the constituent wires breaking at any point and becoming entangled with the gripper on the car. The latter accordingly is sometimes carried along too far in a crowded street until a more or less serious collision occurs.

2. In case of a break or other damage occurring in the cable, a great amount of trouble and expense becomes necessary to effect the proper repairs.

3. The efficiency of cable systems is extremely low; in many cases not more than 25 per cent. of the power given out at the head station is utilised in driving the cars.

4. The cars cannot be regulated so far as their speed is concerned, nor reversed in direction; if they move at all, they must travel at one uniform speed—that the cable—and in the same direction.

It is hardly necessary to say that not one of these objections will be found to apply in the case of electric traction; on the contrary, it may be said with truth that motors of this kind possess all the advantages to be offered by steam locomotives, wire ropes, or horses, and most of these advantages indeed in much greater measure.

Thus, horse traction is easily applied, and involves no structural alteration of the streets, either above ground or below; in the same way, electric accumulator cars possess both these good points, and are, moreover, much more cleanly, of better appearance, and presenting no cruelty whatever to animal life.

This latter item will be appreciated the more by those who are aware of the fact that a tramcar horse's life is usually not longer than two years, or at most three, owing to the heavy strains that it is continually being called upon to undergo.

Again, cable traction is strongly advocated for use on lines that are built with heavy gradients; it is, indeed, sometimes asserted that wire rope transmission then becomes the only possible method to be successfully adopted.

But there are few, if any, streets or public roads conveying any traffic at all which have a greater incline than 1 in 10; yet electric cars have repeatedly climbed such gradients on the wettest and muddiest of days, with ordinary loads and in actual daily working.

Lastly, the steam tramway locomotive is upheld by many as offering the best means available of working a rapid transit line, where heavy cars and loads require to be moved at the maximum speed permissible on crowded roads and streets.

The speed of electric cars, however, is limited only in a theoretical sense—that is, the majority of electric motors could propel the cars just as readily at a speed of 20 miles as at seven. By using spur wheels or other gear, the actual motor speed is reduced considerably, so that the car itself shall not exceed a normal velocity. Even as it is, however, the range of speed in the ordinary electric tramcar is very wide, varying from 10 or 12 miles downwards.

"Since not only on levels, but also on up and down grades, an electric car can be run much faster than a horse car, and because it can be got under way and stopped much more quickly, the mileage with any given number of cars can be increased, the mean running speed increased and the same time-intervals made with a less number of cars, or, on the other hand, shorter intervals be made with a given number of cars.

"The equipment will occupy far less space, the horses being done away with; and this fact, together with the ability to back when necessary and to quickly make headway, enables an electric car to work a passage through traffic where horse cars would be at a standstill."

Not only can electric cars run downhill faster, but also with more safety. If the brake chain parts, the driver can instantly reverse the motor, and so stop the car. Frequently on a grade of 1 in 10, with a loaded car, the brakes have been thrown off, the machines reversed, and the car stopped and started backwards uphill within less than one half its length.

The faster a motor runs, the better; there is no need to hold it in to save it, as might be done with horses.

"The riding of an electric car is far easier than that of any cable or horse car, starting and stopping more easily, and being in a large measure free from lurching and oscillation.

"The cars are much cleaner. They can be brilliantly lighted, and, if necessary, even heated by electricity.

"Stables, with all their unsavoury characteristics and the consequent depreciation in the value of adjacent property, all disappear.

"No sand is needed on the streets to secure better foothold for the horses, and the street paving is not so quickly worn out. It is not claimed that any one system of electric traction has all these advantages; but in some form or other they will be found."

Questions affecting the electric motors themselves will come under the attention of engineers rather than the general public; but in so far as their qualities are of public interest, they deserve at least a few passing comments.

For purposes of electric traction they are pre-eminently adapted: they are low in price, require the smallest amount of attention, are clean and silent, can be started, varied in speed, or stopped with the greatest readiness, they occupy a minimum of space in proportion to their output, and may be used in any situation.

They possess a practically perfect power of self-control, not only over the rate of speed with varying load, but, what is of equal importance, over the energy absorbed; for they help themselves, as it were, to just so much energy from the dynamo generator and steam engine as will enable them to deal with the work imposed upon them.

It is therefore small wonder that electric motors should appear to have marked out for themselves a special field amongst rail and tramway lines: each succeeding year has seen electricity progress in this direction far more rapidly than any other motive power.

There is a peculiar fascination about electricity in the known fact of its adaptability to so many forms of usefulness, all conducing to the comfort and well-being of the human race.

The sight of a car propelled, signalled, and lighted by means of electricity is most attractive, not only to railway men, but to everyone who has occasion to ride in the car.

Street railways have perhaps come to be looked upon as implying of necessity the rapid using up of horses; and for reasons of humanity, if for no other, railway engineers will do all they can to substitute some other motive power for that of animals.

If it is shown that such other method can be adopted and put into daily practical use at a less cost than with horse traction, there obviously is no excuse remaining for the union of horses with tramcars.

DISTRIBUTION OF POWER BY ALTERNATING CURRENTS: PRELIMINARY STATEMENT.

BY WILLIAM STANLEY, JUN., AND JOHN F. KELLY.

As the series of articles now appearing in *La Lumière Electrique*, by M. Leblanc, on the distribution of power by means of alternating currents directly bear upon certain investigations made by the authors on the same subject, we desire to make a preliminary statement of our work.

As is well known, the principal difficulties encountered in operating motors by alternate current are caused by self-induction in the field and armature circuits. But for the presence of this factor, an ordinary shunt or series wound motor properly designed to avoid Foucault currents would operate equally well upon alternate currents of any frequency. When such a motor is supplied with an impressed alternating E.M.F., the self-induction of the field and armature coils causes the currents which flow through them to lag behind the impressed E.M.F. in a manner well understood by electricians. In the case of a shunt motor, it is obvious that the self-induction of the field circuit would oppose the flow of current through it to such an extent as to practically destroy all of the magnetism requisite to operate the motor, and as the self-induction of the field in a shunt motor is very much greater than the self-induction of the armature, the lag of such field current as does leak through against the E.M.F. of self-induction would obviously be much greater than that of the current in the armature. In short, the field and armature magnetisations would be out of phase, and the values of the currents flowing would not represent the torque developed. For the purpose of avoiding these difficulties, the authors have employed a method of annulling the self-induction of a circuit, which, although mathematically expressed by certain writers previous to their work, was but vaguely understood. Briefly stated, this method consists in producing in the circuit possessing self-induction a capacity effect which, when properly chosen for the frequency and self-induction of the circuit will entirely neutralise the counter E.M.F. of self-induction. Consider a circuit possessing a self-induction of L henrys supplied by an impressed E.M.F. of frequency n, it can be shown that if a capacity of M microfarads be inserted in series in the circuit of such value that $M = \frac{10^{-6}}{4 \pi^2 n^2 L}$ there will be developed an E.M.F. within the condenser which will be equal in value to the E.M.F. of self-induction, and as it is 180deg. distant from the E.M.F. of self-induction, it will entirely neutralise this E.M.F. during every instant of time. In short, there will be three E M.F.'s upon the circuit: First, the impressed E.M.F.; second, the E.M.F. of self-induction in quadrature and lagging behind the first; and third, the E.M.F. of the condenser in quadrature, and in advance of the impressed E.M.F.

The accompanying sketch and diagram illustrate the relative positions of these E.M.F.'s. It is not to be understood, of course, that the E.M.F. of self-induction and the E.M F. upon the condenser disappear or are destroyed by the balancing conditions mentioned above, but that as their values are equal and opposite, their effect upon the current flowing through the circuit is neutralised.

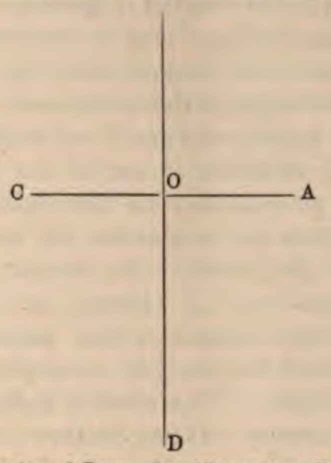

FIG. 1.—Distribution of Power by Alternating Currents. O A= impressed E.M.F. ; O B=condenser E.M.F. ; O D=self-induction E.M.F. ; O C=R I.

As is well known, the counter E.M.F. of self-induction is a function of the current flowing, being $E_s = L\,2\,\pi\,n\,c$, also the back E.M.F. upon the condenser is a function of the current—viz., $E_c = \frac{c\,10^6}{M\,2\,\pi\,n}$. If the values of L and M be chosen such that $L = \frac{10^6}{4\,\pi^2\,n^2\,M}$, then the E_s of self-induction will be equal (and opposite) to the E_c for all values of current flowing through the two in series—that is, E_s and E_c will neutralise for all values of current so long as L and M are constant. When these conditions present in a circuit the value of the current derived from an impressed E.M.F. will be equal to the E.M.F. divided by the resistance. But for the purpose in hand a more important result is attained—viz., the lag of the current behind its E.M.F. is avoided, for there is now no active E.M.F. in the circuit except the impressed, and it is evident that the current must coincide in phase with this E.M.F.

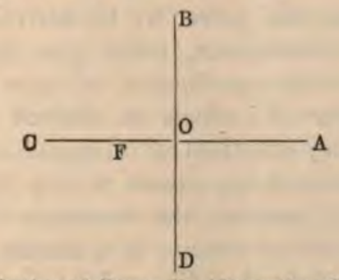

FIG. 2.—Distribution of Power by Alternating Currents. O A= impressed E.M.F. ; O B=condenser E.M.F. ; O D=self-induction E.M.F. ; O F=counter E.M.F. of rotation ; F C=R I.

We have stated that when a condenser is inserted in the circuit of such size as to develop an E.M.F. of equal value to the E.M.F. of self-induction the current flowing will obey Ohm's law. This is, however, only true in the case of a self-induction which does not include an iron core, and it is likewise only true when the condenser is a theoretically perfect receiver, in which none of the energy stored is wasted. In our experiment, to develop a motor which shall operate upon standard alternating circuits we have employed the ordinary type of two-pole motor, with armatures of both open and closed circuit construction, and we have succeeded in entirely neutralising the self-induction of the circuits in a perfectly satisfactory manner. In short, we have been able to apply alternating currents to the ordinary type of motor possessing great self-induction, and to develop the field magnetisation in the same manner as though the motor was supplied with direct currents of constant value. In developing this subject we have met with many phenomena which are almost outside of the range of ordinary alternating-current work, and which we hope to place before the electrical public in a short time. It seems to us that the solution of the problem of the distribution of power by alternating currents is very near at hand.

It is but fair to state that our work in our condenser motor was theoretically completed before the discussion of the Ferranti effect and the publication of the articles on self-induction and capacity that appeared in the foreign electric journals.

As pointed out above, the self-induction of a circuit can be completely neutralised for a given frequency by a certain capacity interposed in the circuit, so that for this particular frequency the circuit offers no opposition save that due to ohmic resistance. It is obvious, however, that for all other frequencies an opposition other than that of ohmic resistance will appear, for higher frequencies due to an unbalanced self-induction, for lower to an unbalanced capacity. It is clear, however, that as the capacity introduced continues to neutralise the self-induction to some extent for all frequencies, all rates above the normal will get through more readily than if no capacity were present, although the farther they are from the normal the less will they be helped. It is otherwise with lower frequencies. Here the opposition is due to the capacity the new element introduced into the circuit, and for rates a certain amount below the normal the opposition offered by the unbalanced condenser is greater than that previously afforded by self-induction alone. The turning point is that at which $n = \frac{n_1}{\sqrt{2}}$ when n_1 is the frequency for which the circuit is balanced, and n any other rate. When $n = \frac{n_1}{\sqrt{2}}$ the current will get through equally well whether the capacity is present or not; when $n < \frac{n_1}{\sqrt{2}}$ it gets through with more difficulty in the presence of the capacity.

We have applied this principle to a method of sifting out different rates of alternation with remarkable success. By its means we are enabled to practically suppress the troublesome currents in telephone lines due to induction and leakage from electric light, electric power, and telegraph circuits. It is, in fact, necessary merely to break the telephone circuit by a condenser of such a capacity as to let the telephonic currents readily through, while opposing a great opposition to the foreign currents of much lower frequency.

Another application of the method is to multiple telegraphy. We can send over a line a current compounded of a number of different wave-lengths and sort these out at the other end, either by leading them into branch circuits separately balanced, or by allowing the compound current to act inductively on a number of local circuits so balanced.—*Electrical World* (N.Y.).

CITY LIGHTING.

The Brush Company have had 26 of their electric lamps running tentatively since last Saturday week—nearly a fortnight. These lamps have usually been lighted at about half-past eight to nine, and kept running till midnight, and several times till daybreak. A 20-h.p. boiler was first used in the trial runs, but was not sufficient, and one of 180-h.p. Babcock and Wilcox boilers has been now got to work. Falcon engines are used driving 50 Brush arc lighters. Yesterday evening was set apart for a public view of the lamps, the gas being turned off at nine.

To avoid any misapprehension, it is specially announced that the present lighting of Queen Victoria-street by arc lamps is carried out with a view to obtaining the approval of the engineers to the Commissioners of Sewers to the form and design of the lamps, and must not be construed as a formal commencement of the lighting of that street in accordance with the contract between the Commissioners and the Brush Electrical Engineering Company.

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We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

ROYAL AGRICULTURAL SOCIETY.

Owing to this being our index number, we are compelled to defer our notice of the engines and the electrical apparatus exhibited at Doncaster to our next issue.

OIL ENGINES.

Electrical engineers will have in the near future to take into consideration the value of oil engines for the purposes of isolated installations. In many cases where electric lighting is desired it has been found inexpedient to install it because of difficulties with the prime motors. Gas is not always available, even if it could be manufactured by the Dowson process. We ought in this instance to say that the material for making the gas is not available. Similarly, the use of steam is out of the question, and no natural powers may be obtainable. In these cases, and they are numerous, oil seems destined to come to the rescue. At present the lighting is by means of oil lamps or by candles, and the house owners would prefer the extra cost if oil could be burnt in an engine to produce the electric light. The electric light is far more cleanly and healthy. It has neither in lighting nor in extinction the property of offending sensitive people by any peculiar smell. But it may be asked, are oil engines practical? We think the exhibits at the Royal Agricultural Society's show just over at Doncaster, conclusively proves their practicability. For some time Messrs. Priestman have had an oil engine on the market. More recently Messrs. Hornsby have put the Hornsby-Ackroyd oil engine on the market, and from the cursory examination possible at such an exhibition this engine seems to be in the right direction—more simple and more economical than any of its predecessors. There is yet another oil engine, produced by makers who have longer and more successful experience with the production of gas engines than any other makers in the world. We allude to Messrs. Crossley, whose gas engine has honestly earned a world-wide fame, whose experience in the combustion of gases, and the power to be derived therefrom by suitable mechanism, must give them a great advantage in the production of any engine the motive power of which is derived from such sources. They exhibited an oil engine at Doncaster which in external appearance is very like their gas engines. At present, the economy of these oil engines of various makers is a matter of hearsay. Each maker feels that the end has not come, and is not over anxious to have an exhaustive trial. They can see small improvements in minor details, and hope each improvement may lead to further economy. Taking these makers in order—Priestman, Hornsby, Crossley—hearsay evidence points to the last-named firm producing an engine slightly more economical than the second-named firm, and that of the second being more economical than that of the first.

The question of economy at present is the consumption of oil per indicated horse-power hour, and in the engines referred to is said to vary from something under a pint of oil to about a pint and a half. Sooner or later, no doubt, indicator diagrams and careful tests will decide more nearly the position the various engines will take in regard to each other.

THE CENTRAL LONDON ELECTRIC RAILWAY.

The preamble of the Central London Railway Bill, which the Select Committee of the House of Lords have had before them this week, is held by the committee to have been proved. The Bill may therefore be considered to be practically passed, as it has already been before the House of Commons, and it is not likely there will be any absolutely obstructive alteration in the scheme as it now stands. The indication of success of the City and South London Underground Electric Railway has, it is evident, been the main factor in deciding for the granting of powers to institute a similar electric railway along Holborn and Oxford-street—from St. Paul's to Shepherd's Bush. The railway is to be of a similar nature to the South London line, consisting of two tubes 10ft. diameter, forming small tunnels run bodily through the earth 50ft. or so below the street, far below the sewers and drain-pipes, the street level being reached by means of huge hydraulic lifts.

The era of electric suburban railways may now definitely be considered as having set in, with the full favour of engineers, Press, and public. The immense increase in the traffic of London has long necessitated some further means of rapid transit; electricity was expected to solve, and has solved, this great question, and a large part of the credit for this result must be attributed both to the mechanical engineers of the original company who designed and carried out the underground tube tunnels, and to the electrical engineers, Messrs. Mather and Platt, for bringing the electrical part of the undertaking to such an engineering success. The insane opposition to the scheme on the part of persons who feared that an additional means of communication would deprive the shops of customers, has almost entirely died out. The public themselves are greatly in favour of an electric means of traction, and their experience of the underground steam railway and its noisome fumes and heated, vapour-laden atmosphere will readily induce them to travel by electric lines. This is, of course, if there are no corresponding disadvantages; and it will need careful consideration in more than one direction for the Central London Electric Railway to be all that is desired. The travelling public between the City and the West-end of London will be possibly more fastidious than those to Stockwell, and this must, and doubtless will be, reckoned with by the promoters. The depth underground will be no disadvantage if the stations above and below are spacious and light, and the lifts easy and rapid. The air in the tunnels has the enormous advantage of being free from sulphury and steamy fumes, but to be all that is expected it must and ought to be as pure as in the street itself, and the mere presence of travelling crowds in a small tunnel, with no surrounding of open air, causes the problem to be not absolutely so easy as it seems. The light, again, on the South London Railway has curious fits of up and down. It will not be very difficult to assure absolute steadiness, and if the electric trains are to be a luxury as well as a convenience, such points are those upon which it will be judged. But not the least difficult of the points we have ventured at this stage to touch upon is the question of noise and of ease of travelling. If there is one point upon which objection can be found on the existing line, it is that the noise and reverberation is almost intolerable, and the travelling jolty, and far from as smooth and luxurious as an ideal electric train should be. The iron walls or the shape or material of the train are the causes of the noise, which, with care and thought, can probably be almost abolished. The ease of travelling is a matter of level lines and easy springs (possibly paper wheels may be suggested), but at any rate the engineers who are capable of achieving such promising and useful results as already accomplished, will find little difficulty in adding or adapting the refinements of civilised needs to make the Central London Railway not only a great engineering and electrical success, but a pleasurable and healthy and convenient means of travelling within the confines of the busy metropolis.

BARNET.

So Barnet is to return to gas. At any rate that is the last decision of the authorities, and, consequently, the gas interests are jubilant. These said interests have from the start to finish made a dead set at Barnet. They have been like a pack of wolves hanging on the skirts of a drove of buffaloes, intent on destroying the weakest one. It is wonderful how convenient it is to the gas journals to forget how many authorities have quarrelled with gas, to think how many have even tried oil. We have no intention of exonerating the engineers at Barnet. No doubt mistakes were made from the commencement, and many difficulties arose from putting down temporary plant. Once an installation is started it is expected to run continuously and well. In some lighting, then, it is very doubtful policy to arrange for temporary work in order to have the light going a few weeks earlier. The moral of Barnet should be taken to heart. Unless fully prepared with permanent plant, better delay the lighting or let someone else carry it out who is so prepared. There is, however, another solution to the mystery of this "going back." It is that the electric light contract expires in August, and that the contractor has not tendered for a renewal, though when this refusal is analysed it may be deemed a compulsory refusal. The contractor and the Local Board have not been the best of friends, and the contractor has brought a claim for £5,000 damages against the Board for refusal of assent to a provisional order.

If the Board's contention is correct, as given in the local papers, and the lighting has been unsatisfactory, there is a strong argument in favour of refusal to assent to an order. It is childish rubbish at this time of day to attempt to maintain that electric lighting may fluctuate like the will-o'-the-wisp, and still be considered satisfactory. Consumers pay for light, and if they do not get it, or do not get it constantly, are perfectly justified in complaining. At the time of the installation of the light at Barnet we argued strongly in favour of giving the contractor the necessary time to perfect his permanent plant, and if latterly the light has really been as its opponents represent it, we cannot condemn the action of the Board. The moral still remains.

THE COLLIER AUDIBLE TELEPHONE.

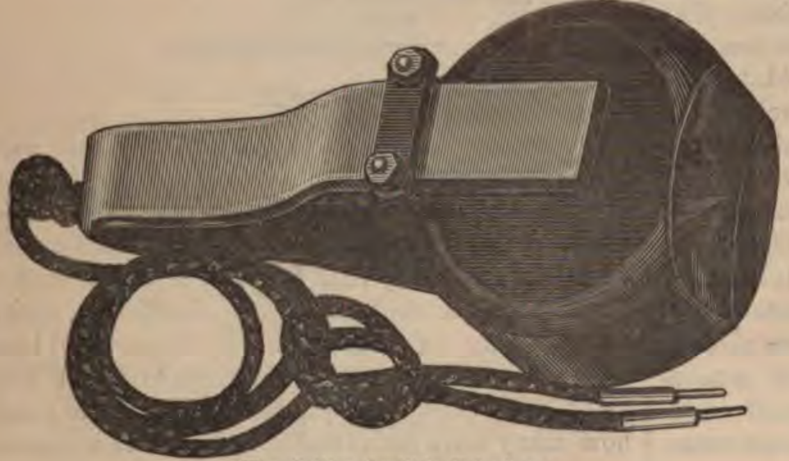
The telephone will be the object of much discussion, of rapid organisation, and possibly of sharp business or legal action in the next few months. In July the carbon transmitter patent will run out. The Bell telephone is now open to the world, and already considerable progress has been made in the organisation of exchanges with Bell instruments alone by the Mutual Telephone Company in Manchester and elsewhere. The great telephone companies will have to look very sharply to their laurels, and none will be surprised and few disappointed if these monopolists, who have so long held the field without having done much to deserve it, are ousted from their position. Added to the present situation of the expiry of master patents, the introduction of a far more powerful receiver than any hitherto known would have a powerful effect in the extension of telephonic systems, if conjoined, as it should be, to double-circuit wires, ready and courteous attention, and the best skill of experienced electricians.

We here wish to speak of a new departure, not in transmitters or switches, but in the telephone receiver itself. To double or treble the sonorousness and audibility of the telephone receiver is no mean achievement, and would hardly be deemed possible were it not obtained by such simple and easy means.

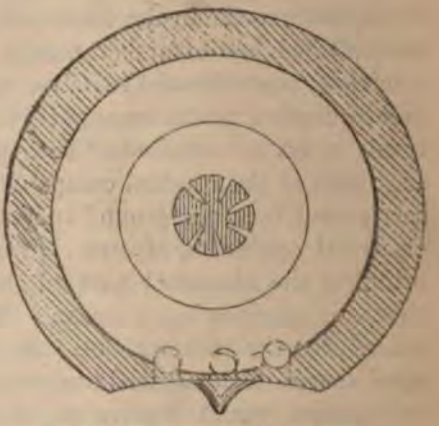
The Collier audible telephone, which we illustrate herewith, is, curiously enough, not the invention of any of the telephone engineers or employees, nor even of a professed electrician, but of a Congregational minister, Mr. Arthur T. Collier, of Sydney, New South Wales. Mr. Collier, being greatly interested in electrical and mechanical work, and hitting upon the idea of his telephone, has given up for a time his charge in Australia, and is now residing in England, bent upon the introduction of his invention. A syndicate has been formed, having offices in 38, Gray's-inn-road, and works on some scale are being established in Manchester.

So much by way of preface. The telephone itself embodies two simple ideas, for the embodiment of which patents have been taken in England, America, and the colonies, etc. These are (1) the employment of a soft iron armature placed directly in between the poles of the magnet, thus using two poles, and with this two vibrating diaphragms—one between each pole and the core; and (2) the method of taking the sound of the vibration from inside the diaphragm box instead of outside, as now usually done. This latter arrangement in itself gives a greater volume of sound by reason both of the greater activity of the magnetisation and also from the additional magnetic variations that go on in the core—effects that have been already noticed, but not used. By combining these ideas and using two diaphragms the telephone receiver is rendered far more sensitive, and its sound very much louder and more distinct. So much so is this, that the sound from a Collier telephone entirely overpowers that from a Bell receiver on the same circuit, almost as a person shouting against a whisper. The sound is almost of a sufficient volume to fill a small room; and it is stated that the difficulty with the telephones in India—viz., that the natives of one caste will not use the instrument placed against the ear of a native of another caste—is now obviated, as it is not necessary to place the telephone close to the ear in order to hear speech.

The construction of the Collier telephone is seen in the detail drawings. The core of soft iron, laminated both end and lengthwise, is mounted on an insulating reel, and wound with wire. It is then mounted into a solid block of ebonite, having a ring turned out, as usual, to grip the metal diaphragm. On either side is a pole-piece, the two forming the poles of the magnet, each nearly touching the diaphragm. The magnet itself is placed outside the whole, its N. and S. pole enclosing the diaphragms in a strong magnetic field. From the inside surface of the two diaphragms three small holes are led up each side to the mouthpiece of the telephone. This mouthpiece has a small cone, as shown, to lead and concentrate the sound into the ear. The result is extraordinary. Not only is the sound very loud—painfully so when the ear is too close—but the delicacy of this instrument, according to tests taken, is phenomenal. The instrument fitted with the iron pole alone, *without any magnet*, is found louder than the ordinary double-pole Bell form of telephone, now, perhaps, the most powerful receiver.



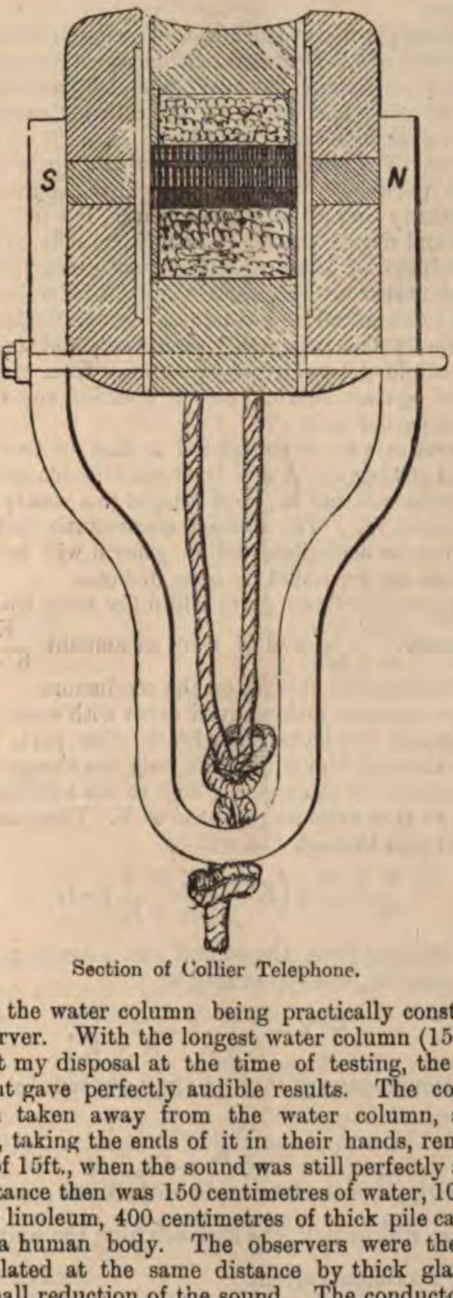
The Collier Audible Telephone.



Side View, Showing Iron Core.

With the complete instrument the delicacy seems almost without limit. From the experiments undertaken upon the Collier telephone, Mr. W. Fereday Bottomley, manager of the Telephone Company of Ireland, says: "I have made a number of tests under different conditions with the instrument, with and without transmitters, and under all circumstances there can be only one opinion—that the Collier instrument is unsurpassed, and will be generally preferred in practice. From the experiments made, I am satisfied that conversation with this instrument, without the aid of a microphone, could be carried on with distinctness and comfort over a line of 5,000 miles."

This is pretty strong testimony, but a further practical test will show the sensitiveness of this instrument in even still more forcible form. Mr. William E. Heys, M.I.E.E., of Manchester, says: "I beg to report that I have carefully tested a pair of your telephone receivers, and find them immeasurably superior to any other instrument which I have ever examined in their susceptibility. I estimate its loudness as being from three to four times greater than that of the best examples of the 'double-pole Bell' and 'Ader' instruments. In arranging the resistances I have been careful to avoid coiled wires or parallel circuits. In order, also, to eliminate any disturbing influences, I have avoided the use of a battery in the circuit and carbon transmitters, the best of which are variable. In making all my tests I used a 'Collier' telephone as a transmitter. The source of sound employed was a metronome rigidly fixed relatively to the transmitter, care being taken to keep the spring of the metronome at about the same tension in all the experiments. The resistances employed were a column of pure water 4 mm. in diameter, and a carbon film on oiled paper. The instrument used as a basis for comparison was a double-pole Bell of first-rate efficiency. With the water column the sound of the metronome disappeared altogether at from 6 to 18 centimetres with the Bell instrument with different observers, the length of the water column being practically constant for each observer. With the longest water column (150 centimetres) at my disposal at the time of testing, the Collier instrument gave perfectly audible results. The conductor was then taken away from the water column, and the observers, taking the ends of it in their hands, removed a distance of 15ft., when the sound was still perfectly audible. The resistance then was 150 centimetres of water, 100 centimetres of linoleum, 400 centimetres of thick pile carpet, all dry, and a human body. The observers were then carefully insulated at the same distance by thick glass, with only a small reduction of the sound. The conductors were thickly insulated; and proof that the current must have taken the course indicated is found in the fact that immediately the observer broke the circuit by dropping the wire, the sound ceased. The experiments with the carbon film gave corresponding results. I have not attempted to take the ohmic resistances, because I could not find any measurable resistance which excluded the sound with the 'Collier' telephone. Electrically, the 'Collier' telephone is far more than 10 times and phonically more than three times more effective than the best 'double-pole Bell' or 'Ader' instruments."



Section of Collier Telephone.

We understand that the Collier telephone has received careful tests and great commendation from Mr. A. R. Bennett, of the Mutual Telephone Company, who has suggested a shape which is now being manufactured, very similar to the usual Bell instrument, to which exchange subscribers are accustomed. An order for 500 of these telephones has been given on their merits by one of the large English railway companies. A really loud-speaking telephone will be of immense use to the railway companies, not only for ordinary messages, but even for a simple form of sounder, and the possibility of communication from guard to engine driver is also to be considered. When the telephone patents are definitely free, a very large field will be open for their use in railway working, till now almost unoccupied. The possibility of sending signals by means of a simple core and two diaphragms without magnets also opens up a new vista, and may develop important consequences, while the extreme sensitiveness of the instrument may make it invaluable in research work.

We may also add that the Collier Audible Telephone Syndicate is backed by the London and Colonial Finance Corporation, and a company is intended to be shortly formed whose shares will be offered to the public. We have little hesitation in saying that Mr. Collier seems to have hit upon a very good idea, and there is every evidence, from the samples of work we have seen, that he is able to carry out his invention in a thoroughly practical and useful manner.

ELECTRICAL EXHIBITION AT TAUNTON.

It is proposed to hold an exhibition of electrical engineering at Taunton from Aug. 1 to Oct. 31, on the ground adjoining the Taunton Electric Light Co.'s central station, St. James's-street. The manager and secretary is Mr. Harry C. Wilson, A.I.E.E., of the Bath Electric Light Works. The exhibition, which is held on the suggestion of Mr. Massingham with the co-operation of the Bath, Taunton, and Exeter Electric Companies, will comprise the following: (1) Lighting by Electricity, (2) Heating by Electricity, (3) Machines, etc., for Producing Electrical Currents by Mechanical Power, (4) Electric Motors and their Applications, (5) Electric Welding and Brazing, (6) Electric Batteries, Primary and Secondary, (7) Apparatus for Electrical Measurements, (8) The Phonograph, (9) The Telephone, (10) Electric Telegraphs and Electric Signals, (11) Electricity in Surgery, (12) Electro-Plating, (13) Applications of Electricity in various ways not specified above, (14) Steam Engines, Pumps, etc., (15) Gas and Oil Engines, and (16) Models of all descriptions. Power will be provided by the Taunton Company at 4½d. per Board of Trade unit, and the exhibits must be in by July 27. Certain spaces are intended to be fitted up as drawing and dining rooms, library, billiard-room, kitchen, or bedroom, to show the artistic treatment of electric lighting, for the interior of private residences. Exhibitors of fittings can, if they desire, arrange with any firm to do the furnishing, the cost for space to each exhibitor being thereby greatly reduced. The exhibition will be open daily from 2 p.m. to 10 p.m. Taunton being the centre of the West of England and South Wales district, situated on the main line of G.W.R., and the junction of four branch lines of railway, it is confidently expected from the success of other exhibitions held in the town that an unusually large attendance of visitors will occur. It is proposed to run an electric omnibus between the exhibition and the G.W.R. station during the whole time the exhibition is open, as well as the placing of one or two electric launches on the River Tone, which has of late been greatly improved by widening and deepening at the expense of the Town Council. The electric light is rapidly extending and becoming very popular in the West of England and South Wales. Besides Bristol and Plymouth many other towns are preparing to follow the examples of Bath, Taunton, and Exeter, so that it is evident there is a large field for the supply of fittings of all kinds and instruments, as well as dynamos, and engines, either steam, gas, or water, for private installations.

SAUNDERSON ARC CARBONS.

We are disappointed at not hearing further with reference to what appeared a considerable improvement in arc light carbons—we allude to Saunderson's carbons with asbestos wick and hydrocarbon grease for feeding up the core of the lower carbon. The report of Dr. Hopkinson showed that a gain of 88 per cent. in the light was achieved with these carbons for the same expenditure of energy, but as far as we are aware no practical use has yet been made of them. This may be due to the fact that the invention has not been put into a practical form; on the other hand, it may be that in practice a sufficiently good result is not attainable, or that the disadvantages balance its advantages. It is natural to suppose—which is, we believe, the fact—that for an enhanced light the carbon consumption is also greater. This means that with the same current a greater light is obtained for a longer length of carbon burnt in the lamp—in other words, for the same carbon burnt in the engine and more in the lamp nearly double the light is given. Taking the condition that the light in the lamp is to be kept the same as at present, the consumption of carbon in the lamp would be the same as now, and as the watts per candle-power are less, the consumption of coal for the engine would evidently be less. If, say, with 300 arc lamps now requiring a 250-h.p. engine the same light might be given with a 150-h.p. engine, the gain would be more than evident. How is it, then, that the invention is not adopted? The extra cost of the carbon is very small—6 per cent. over the present cost has been named. The reason of the non-adoption appears threefold: Firstly, the Saunderson carbon has not been manufactured on a marketable scale; secondly, it has not as yet been proved whether double the amount of light can be obtained in actual practical lighting without any corresponding advantages; thirdly, the dynamos and lamps now in use are constructed for the present size, kind and length of carbons, and to introduce a new kind would probably entail the modification of all the lamps, and possibly also the dynamos. The three companies who do most arc lighting in the country—on the Brush, Thomson-Houston, and Brockie-Pell systems—are those most interested in the question of arc carbon consumption, and until they are convinced of its utility, the hollow core carbon with hydrocarbon feed proposed by Mr. Saunderson, will remain for other persons merely an interesting theoretical improvement.

A FEW CALCULATIONS ON ELECTRICAL SHOCKS FROM CONTACT WITH HIGH-PRESSURE CONDUCTORS.*

BY MAJOR P. CARDEW, R.E., MEMBER.

In connection with the public supply of electrical energy in which very high pressures are used, it is important to investigate the amount of shock to which persons may be exposed by contact with one conductor under various conditions of insulation and electrostatic capacity of the conductors. Serious attention is now being directed to the effect upon the human organism of shocks with steady, intermittent, or alternating currents, and the necessity for exact electrical measurement in such investigations is fully recognised.†

The present opinion upon the subject may be stated to be, roughly, as follows: The effect of an electric shock produced by the passage of a current through the body during an appreciable time is probably proportional to the square of the current, as regards injury by destruction or heating of tissue, with all kinds of currents; while alternating and intermittent currents produce, in addition, effects upon the nerves and nerve-centres which may be directly injurious in themselves, and are generally indirectly so by producing temporary paralysis, and thus depriving the recipient of the power of terminating the period of contact.

The resistance opposed by the body to unidirectional and to alternating currents of the ordinary frequencies appears to be different, at any rate for low electrical pressures, that with the former being considerably the higher; but this difference diminishes as the pressure is increased, and is probably an effect of polarisation in the tissues.

The resistance is also largely affected by the extent of surface of the body through which the current enters, and the condition of the skin.

Without dealing further, however, with the effect produced, the following calculations merely give the current, or discharge through the body, under different conditions; the electrical impedance to the flow to earth through the body, including the resistances at the point of contact and in the earth connection, being taken as a constant resistance—r for continuous, and r' for alternating currents. The charging source is considered to be in all cases perfectly insulated, of negligible electrostatic capacity, and of ample power to maintain the pressure under all conditions.

The principle upon which the following calculations are based is that every electrical machine must at any instant or during any time, however extended, produce equal quantities of what used to be called "positive" and "negative" electricity.

This fact is as true of a dynamo as of a piece of sealing-wax and its rubber; the emission from the source, whether it be a steady current or a small charge, is equal from the positive and negative pole. Thus, if one pole be connected to a conductor of large capacity, it will necessarily be at a potential nearer to the earth than the other pole, if the latter be connected to a conductor of small capacity, and the whole system thoroughly insulated; and in every case this principle determines the potentials from earth of any electrified system, leaving out of question any extraneous charge imparted to it.

The first case to be considered is that of two perfectly insulated conductors, A and B, of considerable cross-section, and capacities K and K′, kept charged to a steady difference of potential, V. The mutual electrostatic induction is assumed to be negligible, and in general will be so, as the conductors are separated by some distance.

The potential of the earth will differ from that of A by an amount $\frac{K' V}{K + K'}$, and of B by an amount $\frac{K V}{K + K'}$, and there will be equal charges on the conductors.

If now a person making good earth with some part of his body touches conductor A with another part, the transmission through him will be not only the charge on A, but the equivalent of the opposite sign to the additional charge flowing to B to raise its potential to V. Thus the quantity that will pass through him will be

$$\frac{K K' V}{K + K'} + \left(K' V - \frac{K K' V}{K + K'}\right) = K' V.$$

The emission from the source being again equal in the two conductors, and amounting to

$$K' V - \frac{K K' V}{K + K'} = \frac{K'^2 V}{K + K'},$$

the maximum current through the body will be

$$\frac{K'}{K + K'} \times \frac{V}{r}.$$

Similarly, if contact be made with B, the quantity in the discharge will be K V, the emission from the source $\frac{K^2 V}{K + K'}$ and the maximum current

$$\frac{K}{K + K'} \times \frac{V}{r}.$$

Thus it appears that where the capacities of the charged conductors are unequal, contact with the conductor of least capacity will produce the greatest shock, the quantities passing through the body, and currents, being in the inverse proportion of the capacities in the two cases.

This case is perhaps not very practical, as electric supply mains, unless one was an aerial conductor and the other buried, would be, as a rule, equal in capacity. Also, there would be in any length of mains great probability of sufficient leakage to determine the potentials, irrespective of capacity, with continuous currents.

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* Paper read before the Institution of Electrical Engineers.

† *Vide* the papers by Messrs. Stone, Newman Lawrence, and Harries.

Secondly—Let the conductors, A and B, be concentric tubes, as in the Ferranti mains, B being outside and entirely enclosing A, except at the two ends, where the conductors are connected to the generator and receiver respectively, or to the generator at one end and the other insulated, which is the simpler case to consider.

In this case there will be no inductive action between the conductors and the earth with the conditions postulated for the generating source, and in the absence of any extraneous charge, and the potential of B with respect to the earth will be zero.

For the quantities on A and B must be equal, and no free charge can be given to B by the source unless it is leaky. If the conductors are transmitting working currents, this condition will be modified by the slope of potential on B, which will then, if insulated, be at zero potential at the centre of its length.

The same reasoning holds with alternating currents, but in this case the tendency to low potential on the outer conductor is stronger on account of the capacity current.

In fact, with such a length of cable as is used on the Deptford trunk mains—each main having, I am informed by Dr. Fleming, a capacity of about 15 microfarads between the outer conductor and the earth—it would be necessary to have such a considerable leak on the generator or receiver at or near the point of connection to the inner conductor, to raise the potential of the outer much above the earth, that, considering the pressure on the inner conductor a breakdown must result, and this, even if there were no metallic connection to earth on the outer conductor.

It is obvious, too, that no leakage between inner and outer could affect the potential of the latter, except to the extent due to the resulting current and the resistance of the conductor.

The writer pointed out at the time that the question of the use of an earth connection on these trunk mains was first discussed, that the outer conductor would even without this connection always be at a low potential so long as the circuit was in a workable condition; and he has recently been informed that this is found to be the case at Rome.

The earth connections in use have, however, important functions as safeguards in the event of a breakdown in a main transformer.

It is somewhat curious to note that the charge on the outer conductor on the Deptford trunk mains at any instant does not come from the terminal of the dynamo in connection with this conductor, but from that connected to the inner conductor, and passes through the transformer.

Thirdly—Let the capacities of A and B be negligible, but their insulation be no longer perfect, the insulation resistance of A being R, and of B, R′.

Then with a steady P.D. the potential of A will be $\frac{\mathrm{R\,V}}{\mathrm{R+R'}}$ and of B $\frac{\mathrm{R'\,V}}{\mathrm{R+R'}}$ on the principle of equal emission.

If contact be now made with A its potential is at once reduced to

$$\frac{r\,\mathrm{R\,V}}{r\,\mathrm{R}+\mathrm{R'}\,(\mathrm{R}+r)},$$

and that of B increased to

$$\frac{\mathrm{R'}\,(\mathrm{R}+r)\,\mathrm{V}}{r\,\mathrm{R}+\mathrm{R'}\,(\mathrm{R}+r)};$$

the current through the body being

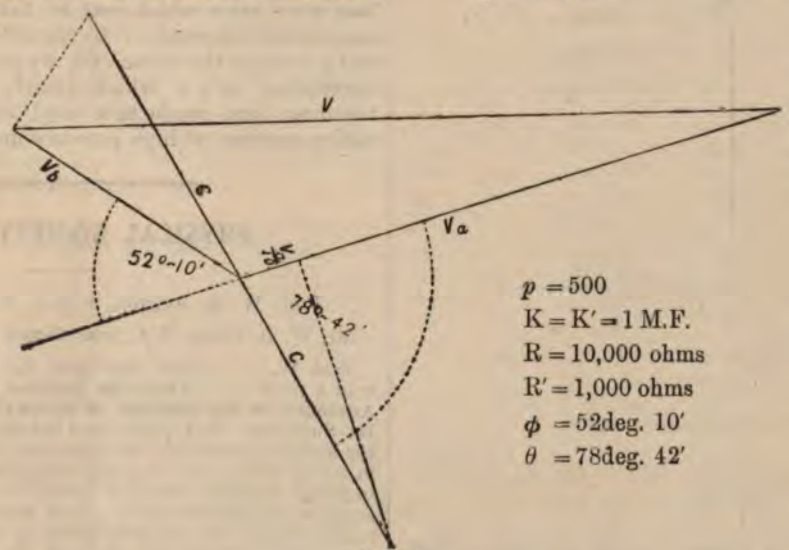
$$\frac{\mathrm{R\,V}}{r\,\mathrm{R}+\mathrm{R'}\,(\mathrm{R}+r)}.$$

If the conductors have appreciable capacity as well as leakage, there will result in every case a discharge through the body due to the rearrangement of potentials with respect to the earth, since the effect of the contact must be to lower the potential of the conductor touched.

Fourthly—The general case with leakage and capacity with alternating currents.

This requires working out. Let, as before, A and B be the two conductors between which an alternating pressure, maximum V, is maintained at a frequency n; and let them be considered to be separate conductors with negligible mutual electrostatic induction.

Let K be the capacity, R insulation resistance } of A.
K′ capacity, R′ insulation resistance } of B.
V_a maximum pressure of A from earth;
V_b maximum pressure of B from earth;
$p = 2\,\pi\,n$.



$p = 500$
$\mathrm{K} = \mathrm{K'} = 1$ M.F.
$\mathrm{R} = 10{,}000$ ohms
$\mathrm{R'} = 1{,}000$ ohms
$\phi = 52$deg. 10′
$\theta = 78$deg. 42′

FIG. 1.

The current at any instant flowing to each conductor will be compounded of the charging and leakage currents respectively, and the phase angle between the pressure and the current for each conductor will depend upon the capacity and insulation resistance, and will not be the same for the two conductors unless the product of the capacity and insulation resistance is the same for each.

But the current in each conductor must be identical in phase, and equal at any instant, on the principle of continuity. Therefore, in general there will be a difference in phase between V_a and V_b, as shown in Fig. 1.

Let ϕ be the angle measuring this difference; and assuming the sine law of variation, we have at any instant the potential of $\mathrm{A} = \mathrm{V}_a \sin \alpha$, and of $\mathrm{B} = \mathrm{V}_b \sin(\alpha + \phi)$, where α is the phase angle; and as the quantity flowing to each conductor in the succeeding instant is the same,

$$\mathrm{K\,V}_a\, d\,(\sin \alpha) + \frac{\mathrm{V}_a}{\mathrm{R}} \sin \alpha\, d\,t = \mathrm{K'\,V}_b\, d\,[\sin(\alpha+\phi)] + \frac{\mathrm{V}_b}{\mathrm{R'}} \sin(\alpha+\phi)\, d\,t,$$

or

$$p\,\mathrm{K\,V}_a \cos \alpha + \frac{\mathrm{V}_a}{\mathrm{R}} \sin \alpha = p\,\mathrm{K'\,V}_b \cos(\alpha+\phi) + \frac{\mathrm{V}_b}{\mathrm{R'}} \sin(\alpha+\phi).$$

Since this equation is true for all values of a, let $a=0$, then

$$p\,\mathrm{K}\,\mathrm{V}_a = p\,\mathrm{K}'\,\mathrm{V}_b \cos\phi + \frac{\mathrm{V}_b}{\mathrm{R}'} \sin\phi \quad . \quad . \quad (1)$$

Again, let $a=\frac{\pi}{2}$, then

$$\frac{\mathrm{V}_a}{\mathrm{R}} = \frac{\mathrm{V}_b}{\mathrm{R}'} \cos\phi - p\,\mathrm{K}'\,\mathrm{V}_b \sin\phi \quad . \quad . \quad (2)$$

whence,
$$\tan\phi = \frac{p\,(\mathrm{K\,R} - \mathrm{K}'\,\mathrm{R}')}{1 + p^2\,\mathrm{K\,K}'\,\mathrm{R\,R}'} \quad . \quad . \quad . \quad (3)$$

The straight line joining the extremities of V_a and V_b represents V in phase and magnitude; whence,

$$\mathrm{V}_a{}^2 + \mathrm{V}_b{}^2 + 2\,\mathrm{V}_a\,\mathrm{V}_c \cos\phi = \mathrm{V}^2 \quad . \quad . \quad (4)$$

From these equations the values of V_a and V_b can be deduced in terms of V; but as the resulting formulæ are somewhat cumbrous, it is simpler to proceed thus: First, determine ϕ from equation (3); secondly, determine θ, the angle between V_a and C, the current, from the equation,

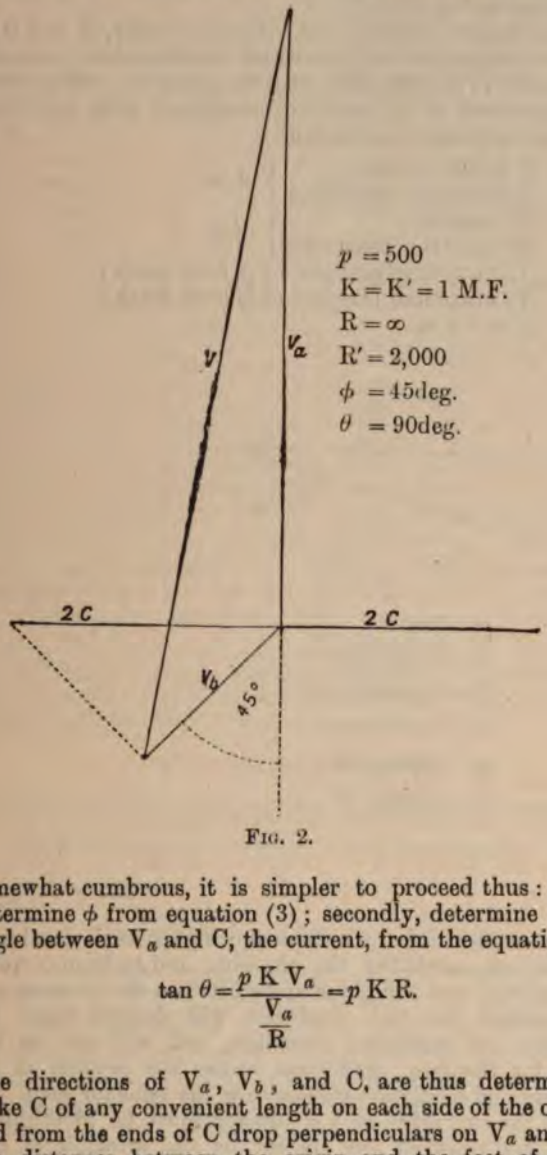


FIG. 2.

$$\tan\theta = \frac{p\,\mathrm{K}\,\mathrm{V}_a}{\frac{\mathrm{V}_a}{\mathrm{R}}} = p\,\mathrm{K\,R}.$$

The directions of V_a, V_b, and C, are thus determined: Take C of any convenient length on each side of the origin, and from the ends of C drop perpendiculars on V_a and V_b: the distances between the origin and the feet of these perpendiculars are proportional to $\frac{\mathrm{V}_b}{\mathrm{R}'}$ and $\frac{\mathrm{V}_a}{\mathrm{R}}$, and may be taken as V_b and $\frac{\mathrm{R}'}{\mathrm{R}}\,\mathrm{V}_a$. This determines the length of V_a and V. In the example shown in Fig. 1, $\mathrm{V}_b = \frac{\mathrm{V}}{2{\cdot}9}$; or the current through the leak $= \frac{\mathrm{V}}{2{,}900}$, maximum.

Fifthly.*—If the insulation of the two conductors be supposed perfect before contact is made with one of them, the equations are simplified.

Let B be the conductor touched, then in the equations R becomes infinity, and $\mathrm{R}' = r'$;

whence,
$$\tan\phi = \frac{1}{p\,\mathrm{K}'\,r'},$$

and
$$\mathrm{V}_b = \frac{p\,\mathrm{K}\,r'\,\mathrm{V}}{\sqrt{1 + p^2\,r'^2\,(\mathrm{K} + \mathrm{K}')^2}}.$$

Thus the maximum current through the body is given by the equation,

$$\mathrm{C} = \frac{p\,\mathrm{K}\,\mathrm{V}}{\sqrt{1 + p^2\,r'^2\,(\mathrm{K} + \mathrm{K}')^2}} \quad . \quad . \quad . \quad (5)$$

or, if V be virtual volts, this will be the current in virtual amperes.

Here again it appears that the discharge through the body varies directly as the capacity, not of the conductor touched, but of the oppositely charged conductor, as has been shown to be the case with unvarying pressure.

Fig. 2 shows the phases and relations of the quantities, V_a in this case being in quadrature with C.

As a rule, with separate conductors the capacities of each with respect to the earth will be equal, in which case equation (5) is modified to the following:

$$\mathrm{C} = \frac{p\,\mathrm{K\,V}}{\sqrt{1 + 4\,p^2\,r'^2\,\mathrm{K}^2}},$$

which may be written

$$\mathrm{K} = \frac{\mathrm{C}}{p\,\sqrt{\mathrm{V}^2 - 4\,\mathrm{C}^2\,r'^2}}.$$

Supposing C, the current through the body, to have the maximum value which may be taken without injury—or, say, 20 milliamperes—r' to be 2,000 ohms, V 2,000 volts, and p to have the value 500, we get from this K about ·02 microfarad only; which clearly shows the danger of touching bare conductors used for the supply of alternating currents at high pressure under any conditions.

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* Cf. "On an Unnoticed Danger in certain Apparatus for Distribution of Electricity," by J. Hopkinson, F.R.S., *Phil. Mag.*, Sept., 1885.

PHYSICAL SOCIETY.—June 12.

Prof. W. E. AYRTON, F.R.S., President, in the chair.

Mr. W. H. Dines, B.A., was elected a member of the society.

Prof. W. G. Adams then took the chair whilst **Prof. Ayrton** read a paper on **"Alternate Current and Potential Difference Analogies in the Methods of Measuring Power,"** by himself and Dr. Sumpner. In a paper read before the society in March last, the authors pointed out that for every method of measuring power in which readings of volts and amperes were taken, other methods in which amperes were read instead of volts, and volts instead of amperes, could be devised. More recently Dr. Fleming had, by a transformation of a formula given by the authors in a communication made to the Royal Society on the measurement of power by three voltmeters, given the analogue in which three ammeters were employed. The two arrangements are represented in Figs. 1 and 2, whilst Fig. 3 shows a modification of Dr. Fleming's method (Fig. 2), in which the current in the non-inductive resistance, r, is measured by the aid of a voltmeter, V, across its terminals. This obviates the necessity of putting an electromagnetic instrument in what should be a non-inductive circuit. The formula for the mean watts spent in the circuit, $a\ b$, Figs. 1 and 2, are respectively

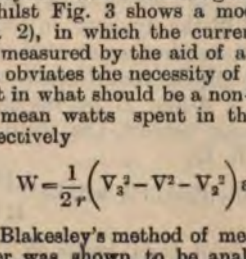

FIG. 1.

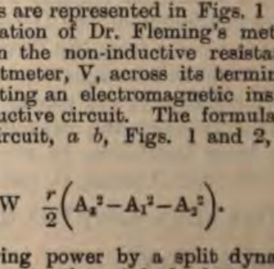

FIG. 2.

$$\mathrm{W} = \frac{1}{2r}\left(\mathrm{V}_3{}^2 - \mathrm{V}^2 - \mathrm{V}_2{}^2\right) \text{and W} \quad \frac{r}{2}\left(\mathrm{A}_3{}^2 - \mathrm{A}_1{}^2 - \mathrm{A}_2{}^2\right).$$

Mr. Blakesley's method of measuring power by a split dynamometer was shown to be analogous to the original electrometer method, in which the difference of two readings was proportional to the power, and Blondlot and Currie's double electrometer method was shown to be the analogue of the ordinary wattmeter. The wattmeter was defective in the fact that a solenoidal coil was inserted in a nominally non-inductive circuit. The error thus introduced is, as was shown by one of the authors some years ago, expressed by the formula

$$\frac{\text{Apparent watts}}{\text{True watts}} = \frac{1 + \tan\theta \tan\phi}{1 + \tan^2\phi}$$

where θ is the phase angle between the current and E.M.F. in the circuit in which the power is to be measured, and ϕ the phase angle for the approximately non-inductive circuit. It is now proved that the same formula expresses the error in any of the methods where resistances not wholly non-inductive are used. As is well known, Mr. Blakesley has applied his split dynamometer to the measurement of phase differences between two currents; and an analogous method of finding the phase difference between two potential differences is described in the paper. In this method a high-resistance split dynamometer such as suggested by Mr. Remington for measuring power is employed. Blondlot and Currie's double electrometer could also be used for the same purpose. Numerous diagrams illustrating the various analogies accompany the paper. **Prof. S. P. Thompson** enquired whether hot-wire voltmeters could be employed to measure the various potential differences without introducing error? In reply, **Prof. Ayrton** said that although no great error was introduced by the self-induction of these instruments, yet the fact that they required considerable current was a disadvantage, and as these currents were not always in the same phase as those in other circuits, troublesome corrections were sometimes necessary. Electrostatic instruments were preferable. **Prof. Adams** said he was glad to hear that the inductance of Cardew voltmeters introduced no serious error, for they were very convenient instruments to use.

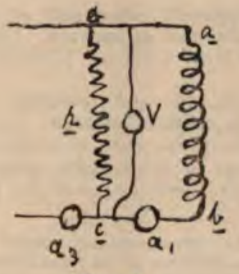

FIG. 3.

Prof. O. Lodge, F.R.S., exhibited and described "**A Clock for Pointing Out the Direction of the Earth's Orbital Motion in the Ether.**" After mentioning the various motions to which a point on the earth's surface in subjected, he pointed out that the orbital motion was the largest component, and its direction at any instant not easy to conceive. An apparatus for pointing out this direction was therefore convenient when dealing with problems requiring a knowledge of the motion of a point through the ether. In one of two clocks shown, one spindle representing the earth's polar axis and another the axis of the ecliptic were inclined at an angle of 23½deg., and coupled by a Hooke's joint. The latter axis was capable of rotating round the former. At its upper end the ecliptic axis carried a tube and a pointer, both being perpendicular to the axis and to each other. The clock keeping solar time rotated both axes, and when properly set the tube pointed in the direction of the sun, and the pointer therefore indicated the direction of the earth's orbital motion.

"**Some Experiments with Leyden Jars**" were then shown by **Dr. Lodge**. The first one was with resonant jars, in which the discharge of one jar precipitated the overflow of another, when the lengths of the jar circuits were properly adjusted or tuned. The latter jar was entirely disconnected from the former and was influenced merely by electromagnetic waves emanating from the discharging circuit. Lengthening or shortening either circuit prevented the overflow. Correct tuning was, he said, of great importance in these experiments, for a dozen or more oscillations occurred before the discharge ceased. The effect could be shown over considerable distances. In connection with this subject Mr. Blakesley had called his attention to an observation made by Priestly many years ago, who noticed that when several jars were being charged from the same prime conductor, if one of them discharged the others would sometimes also discharge, although they were not fully charged. This he, Dr. Lodge, thought might be due to the same kind of influence which he had just shown to exist. The word resonance, he said, was often misunderstood by supposing it always had reference to sound, and as substitutes he thought that symphoning or symphonic might be allowable. The next experiment was to show that wires might be tuned to respond to the oscillation of a jar discharge just as a string could be tuned to respond to a tuning fork. A thin stretched wire was connected to the knob of a jar, and another parallel one to its outer coating, and by varying the length of an independent discharging circuit a glow was caused to appear along the remote halves of the stretched wires at each discharge. Each of the wire thus acted like a stopped organ pipe, the remote ends being the nodes at which the variations of pressure are greatest. By using long wires he had observed a glow on portions of them with the intermediate parts dark. This corresponded with the first harmonic, and by measuring the distance between the two nodes he had determined the wave-length of the oscillations. The length so found did not agree very closely with the calculated length, and the discrepancy he thought due to the specific inductive capacity of the glass not being the same for such rapidly alternating pressures as for steady ones. He also showed that the electric pulses passing along a wire could be caused (by tuning) to react on the jar to which it was connected, and cause it to overflow even when the distance from the outside to the inside coating was about 8in. During this experiment he pointed out that the noise of the spark was greatly reduced by increasing the length of the discharging circuit. The same fact was also illustrated by causing two jars to discharge into each other, spark gaps being put both between their inner and outer coatings, so as to obtain "A" sparks and "B" sparks. By putting on a long "alternative path" as a shunt to the B spark gap, and increasing that gap, the noise of the A spark was greatly reduced. He had reason to believe that the B spark was a quarter-phase behind the A spark, but the experimental proof had not been completed. He next described some experiments on the screening of electromagnetic radiation in which a Hertz resonator was surrounded by different materials. He had found no trace of opacity in insulators, but the thinnest film of metal procurable completely screened the resonator. Cardboard rubbed with plumbago also acted like a nearly perfect screen. In connection with resonators he exhibited what he called a graduated electric eye, or an electric harp, made by his assistant, Mr. Robinson, in which strips of tinfoil of different lengths are attached to a glass plate, and have spark gaps at each end, which separate them from other pieces of foil. One or other of the strips would respond according to the frequency of the electromagnetic radiation falling upon it. **Mr. Blakesley** asked whether the tuning of the resonant jars needed readjustment when the distance between their circuits was varied, for according to theory the mutual induction should diminish the self-induction of the primary, and cause its oscillations to be more rapid. If this was true, the method might be used for getting rapid oscillations. He also enquired whether the glow would appear in the same position on the two stretched wires if their ends were joined. **Dr. Sumpner** wished to know how the resistances, inductances, and capacities of the circuits and jars were determined, and whether any evidence of irregular distribution of the charges on the tinfoil had been noted. With reference to the overflowing of a jar caused by using a certain length of discharging circuit, he asked whether the overflow did not prove the existence of a higher potential than that which originally existed between the coatings of the jar, and, if so, where did the excess energy come from? **Dr. Thompson** asked if it would be possible to make a wire circuit analogous to an open organ pipe by putting sheets of metal on the ends of the wires? **Dr. Lodge**, in reply, said Mr. Blakesley's suggestion was an important one, but he had not observed that any change in the adjustment was necessitated by varying the distance between the resonating circuits. Neither had he noticed any glow on wires joined to form a single loop, but this might be possible if the wires were long enough to give harmonies. In answer to **Dr. Sumpner**, he said that the capacities were difficult to determine, for with such rapid oscillations the coatings were virtually enlarged. Lord Rayleigh had shown how to calculate the inductances, and the resistances he had practically measured by his alternative path experiments. The overflow of jars, he thought, was caused by the charges in some way concentrating on the edges of the foil, thus causing a kind of flood tide at which the overflow occurred. The **President** asked Dr. Lodge what his views were as to the cause of the opacity of ebonite to light. Was it due to a selective absorption, which cut off only the rays to which the eye was sensitive, or was the ordinary explanation that it contained impurities, which were conducting, and hence acted as screens, likely to be correct? Another possible explanation was that the motion of the ether particles may be in three dimensions, and might be due to the projection of this motion on a plane perpendicular to the ray, whilst electromagnetic induction might be due to the other component. **Dr. Lodge** said he believed that ebonite was not opaque because of conducting particles being present, and was inclined to think that it acted more like ground glass, in which the opacity was due to internal reflections. Such a substance would only be opaque to vibrations whose wave-length were comparable with the size of the particles.

A note "On the Construction ot Non-Inductive Resistances," by Prof. W. E. Ayrton, F.R.S., and Mr. T. Mather was postponed until next meeting.

NEW COMPANIES REGISTERED.

Electrolytic Caustic Soda and Chlorine Trust, Limited.—Registered by Walter Webb and Co., 23, Queen Victoria-street, E.C., with a capital of £10,000 in £10 shares. Object: to carry into effect an agreement expressed to be made between James Charles Richardson of the first part, Trevenen James Holland of the second part, and the Company of the third part, for the acquisition of certain patents relating to improvements in the electrolytic production of caustic soda, caustic potash, and other products from their salts, and for improvements in apparatus to be used for electrolytic purposes, and to develop, improve, and bring into public use the said inventions. There shall not be less than three nor more than seven Directors. The first are G. R. Tyler, C. E. Green, R. C. Baxter, R. Vogan, Colonel T. J. Holland, C.B., and J. C. Richardson. Qualification, £500. Remuneration to be determined in general meeting.

COMPANIES' MEETINGS.

HOUSE-TO-HOUSE ELECTRIC LIGHT COMPANY.

The third ordinary general meeting of the House-to-House Electric Light Supply Company, Limited, was held on Friday at the offices, Richmond-road, Kensington, Mr. H. R. Beeton in the chair.

The **Chairman**, in moving the adoption of the report and accounts, stated that the Company had made steady progress during the period under review, although that progress was not quite so rapid as they had expected, due partly to the system of mains having been extended less rapidly during the year. The result, although in strict accordance with the anticipations held out at the last meeting, had been somewhat prejudiced by the increased price of coal. The growth from the commencement had been steadily continuous, and the revenue account related, therefore, only to an average demand. The number of lamps now connected was upwards of 16,000, as against 7,000 12 months ago. Considerable economies had been effected in working. The City office was closed, and the draughtsmen and canvassers at Kensington had been dispensed with. The establishment charges had also been reduced, and they had handed over the installation business to a fittings company on advantageous terms. The amount thus saved was expected to be about £1,000 a year, but the full benefit had not been felt in the period comprised by the accounts. Further economies were also to be made as the result of a capital expenditure which the Directors hoped soon to be justified in incurring, and they looked forward with confidence to a prosperous future. He was not at present in a position to advise any definite progress with regard to the disposal of their construction assets, but the matter was receiving the attention of the Directors.

Mr. R. Hammond seconded the motion, and stated that the work of the Company had been interfered with by the action of the Board of Trade. The parliamentary powers for the Kensington district were held for 42 years on extremely favourable terms. He thought the prospects were very encouraging.

The retiring Directors and Auditors were re-elected.

COMPANIES' REPORTS.

WEST AFRICAN TELEGRAPH COMPANY.

The report of the Directors for the 12 months ended December 31, 1890, states that the Company's revenue for that period amounted to £68,378, against which £21,686 is charged for ordinary expenses; £4,789 for expenditure relating to repairs of cables, etc.; and £639 for income tax, leaving a balance of £41,264. From this amount is deducted £23,694 (being for interest on debentures, £14,027; and for sinking fund, £9,667), leaving a balance of £17,570, out of which the Directors have placed £6,016 to the general reserve fund. The shareholders have received for the six months ending June 30, 1890, an interim payment amounting to 4s. per share, and the Directors now recommend a dividend of 6s. per share, making 5 per cent., free of income tax, for the year ended December 31, 1890, which, with the appropriation to the general reserve fund of £6,016, will absorb the balance standing to the credit of the revenue account.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for last week amounted to £5,628.

City and South London Railway.—The receipts for the week ending 20th inst. were £721; those for the week ending June 13 were £860.

Western Brazilian Telegraph Company.—The receipts ended June 19, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,984.

PROVISIONAL PATENTS, 1891.

JUNE 15.

10121. **Improvements in arc lamp hangers.** Charles Augustus Pfluger, 1, Quality-court, London.

10127. **An electric device for indicating tabulated public information.** Herbert Leslie Manton, 115, Cannon-street, London.

JUNE 16.

10174. **A new and improved method of steering ships, torpedoes, or other floating or moving objects; an improved mechanical or electrical steering gear in connection therewith.** Frank Samuel Pett, 113, Snargate-street, Dover.

10175. **Electrical metronome, or time beater or regulator, for musical and other purposes.** James Walker and Joseph Hampshire, 2, Union-street, Dewsbury.

10220. **Improvements in brush holders for commutators for dynamo-electric machines.** Reginald Walter Barker, Monument-chambers, King William-street, London. Isaac H. Bartholomew, United States.)

10227. **Improved electrical conductor.** Philip Henry Holmes, 47, Lincoln's-inn-fields, London. (Complete specification.)

JUNE 17.

10256. **Improvements in apparatus for signalling by electricity.** Frederick King and William Phillips Mendham, The Western Electrical Works, Bristol.

10260. **Improvements in and connected with electric signalling and lighting in trains, said improvements being also applicable for telegraphic and telephonic communication.** Alexander Shiels and William Elliot, 70, Wellington-street, Glasgow.

10261. **Improvements in reciprocating electric motors.** Henri Pieper Fils, 47, Lincoln's-inn-fields, London.

10280. **Improvements in devices for protecting the ears when using telephone receivers.** William Phillips Thompson, 6, Lord-street, Liverpool. (Rudolf Kolbe and Karl Lischka, Germany.)

10302. **New or improved coin-freed or automatic electro-magnetic induction apparatus.** Christen Rees Bonne, 57, Chancery-lane, London. (Petsch, Kupka, and Popp, Austria.)

10307. **Improvements in and relating to dynamo-electric machines and electric motors.** Carl Coërper, 45, Southampton-buildings, London. (Complete specification.)

10311. **Improvements in electrically driven fans.** Henry Garwood Watel, 21, Finsbury-pavement, London.

JUNE 18.

10332. **Apparatus to automatically make and break one or more electric circuits at any set time or times.** Arthur Douglass, 13, Southampton-street, Pentonville Hill, London.

10347. **Improved electric battery.** Daniel Fitzpatrick, 8, Quality-court, London.

10364. **Improvements in electrical switches.** Arthur Bernard Gill, 4, Bombay-street, Bermondsey, London.

10371. **Improvements in the production of light and the generation of heat and electricity.** Frederick Robert Edward Branston, 83, Commercial-road, Lambeth, London.

10398. **Improvements in telephone transmission.** Joseph Slater Lewis, 53, Chancery-lane, London.

JUNE 19.

10425. **Improvements in or relating to means or apparatus for illuminating roundabouts and the like with electric light.** Frederic William Dickinson, 323, High Holborn, London.

10434. **An electric meter.** Paris Eugene Singer, 6, Victoria-road, Kensington, London.

10451. **An improvement in posts for carrying electric lights and such like purposes.** William Haywood and Charles Henry Driver, 28, Southampton-buildings, London.

JUNE 20.

10481. **Improvements in apparatus for synchronising electric telegraph instruments.** Gilbert Alfred Cassagnes, 115, Cannon-street, London.

10548. **Improved apparatus for mechanically winding electrical wires.** William Sharrow, 21, Finsbury-pavement, London.

10554. **Improvements in connection with the construction and working of transformers or converters.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1890.

7186. **Welding metals electrically.** Thompson (Coffin). (Second edition.) 6d.

8595. **Electric logs.** Granville. 6d.

10183. **Electrical switches.** Lake (Bergmann). 8d.

11499. **Dynamo-electric machines.** Wadley. 8d.

11653. **Electric propulsion of railway electric, etc., vehicles.** Heys (Heilmann). 8d.

11883. **Distributing electricity.** Tomlinson. 11d.

11919. **Lead wire for electrodes, etc.** J. and L. Legay. 8d.

13853. **Producing electricity.** Faure. 8d.

14634. **Electric light signalling.** Inglefield. (Second edition.) 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2½
— Pref.	—	1⅞
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9½
London Electric Supply	5	2¼
Swan United	3½	4½
St. James'	—	6½
National Telephone	5	4⅞
Electric Construction	10	7¼
Westminster Electric	—	4¾